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TECHNICAL DATA ON KC-FILM, TONERS AND PROCESSES.(U)

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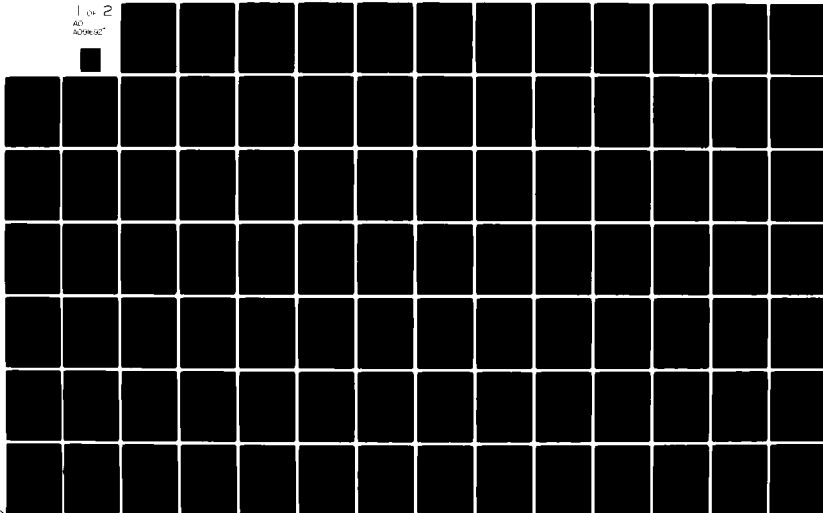
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TECHNICAL DATA ON  
KC-FILM, TONERS AND PROCESSES

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Final Report for Period 13 July 1979 - 13 March 1980

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Prepared for

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Fort Belvoir, Virginia 22060

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The work accomplished includes measurements of the response of KC-Film, toners and processes. Data is included on charge levels, dark decay, voltage-log E response, reciprocity characteristics, as well as spectral sensitivity of KC-Film. This report includes grey scale responses for each of two toner types, including D-max and gamma ranges. Resolution capability is included as a function of toner type, surface voltage, toning time, exposure and image contrast. Resolution data is also provided as a function of time from imaging to toning. Granularity as well as acutance (edge sharpness) determinations are presented as a function of toner type.		

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PREFACE

This report was prepared under Contract DAAK 70-79-C-0116 for the  
U.S. Army Engineer Topographic Laboratories, Fort Belvoir, Virginia 22060.

The Contractor Officer Representative was Mr. Gunther Schwarz.

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## 1.0 INTRODUCTION

Coulter Systems Corporation contracted with the United States Army Engineer Topographic Laboratories to provide technical and programmatic data on its KC-Film, toners and related processes. This contract is titled "Technical Data on KC-Film, Toners, Processes." The Contract No. 70-79-C-0116 started 13 July 1979 and terminates 31 March 1980. This Final Report is submitted in accordance with the Contract Data Requirements List, Item 16.

## 2.0 OBJECTIVE

The objective of this contract is to provide technical data on KC-Film, toners and processes to permit USAETL to evaluate the imaging characteristics of KC materials for those uses USAETL may envision.

## 3.0 WORK ACCOMPLISHED

The work accomplished includes measurements of the response of KC-Film, toners and processes. Data is included on initial charge levels, dark decay, voltage-log E response, reciprocity characteristics, as well as spectral sensitivity of KC-Film. This report includes grey scale responses for each of two toner types, including D-max and gamma ranges. Resolution capability is shown as a function of toner type, surface voltage, toning time, exposure and image contrast. Resolution data is also provided as a function of time from imaging to toning. Granularity as well as acutance (edge sharpness) determinations are presented as a function of toner type.

Two test systems were used to gather technical data on KC-Film; the 39-B system, and a manual precision imaging station. The 39-B system is an automated microprocessor controlled test system which allows for precise control of times between and duration of discrete process functions such as film charging, voltage measurement, exposure and toning. The unit is operator programmable, and allows for complete flexibility in experiment design.

The manual precision imaging system is a unit which allows for charging, voltage measurement, projection or contact printing, and toning of KC-Film. The type of light source on the test system can be varied and allows for exposure durations from less than one millisecond to one second. Various targets are available which enabled the generation of sensitometric and resolving power samples.

Two toners were chosen for evaluation, designated CR-42 and CR-53P. CR-42 is a high resolution, non-fusible toner capable of achieving transmission densities of approximately 3 in relatively short toning times. CR-53P, in addition to being a high resolution toner, may be heat fused at 180°F to produce durable images. Each toner was evaluated at working concentrations of 50, 100, and 200 g/Kg so that any toner concentration dependence could be ascertained.

### 3.1 Electrical Responses

Initial charge levels and corona charging currents were measured; dark decay characteristics were measured, as well as the V-log E response of the KC-material chosen for this study. In addition, the spectral sensitivity of the KC-Film was measured.

### 3.1.1 Charge Levels and Dark Decay

The 39-B system corona current was adjusted to yield the maximum apparent surface voltage on a sample of the 194-1 material. For a film travel speed of 60 mm/sec and a 4-inch corona wire, a corona current of 65  $\mu$ A was found to be the optimum.

The initial charge levels of the film were determined by measuring ten samples taken at equal intervals over 70 meters of the roll. Again using the 39-B system, the mean initial surface voltage was found to be -23V with a standard deviation of 0.52V, or a 2.3% variation in ASV over the length of material examined.

A typical dark decay of the 194-1 material is shown in Figure 1. In the past, we have found it useful to computer fit dark decay data to an integrated, two parameter power law model of the form

$$t_2 - t_1 = A (V_2^B - V_1^B)$$

where A and B are constants and  $V_1$  and  $V_2$  are the film surface voltages measured at times  $t_1$  and  $t_2$ , respectively. This exercise allows us to calculate film voltages at various stages of processing, e.g., when entering exposure station, voltage at time of toning, etc., where no voltage measuring means are available. It should be noted that this model is completely general, and does not require the explicit knowledge of the surface voltage at  $t = 0$ . For the material of current interest, values for the constants A and B were found to be  $1.50 \times 10^7$  and -4.88, respectively, as shown in Table 1.

Figure 1  
194-1 Dark Decay

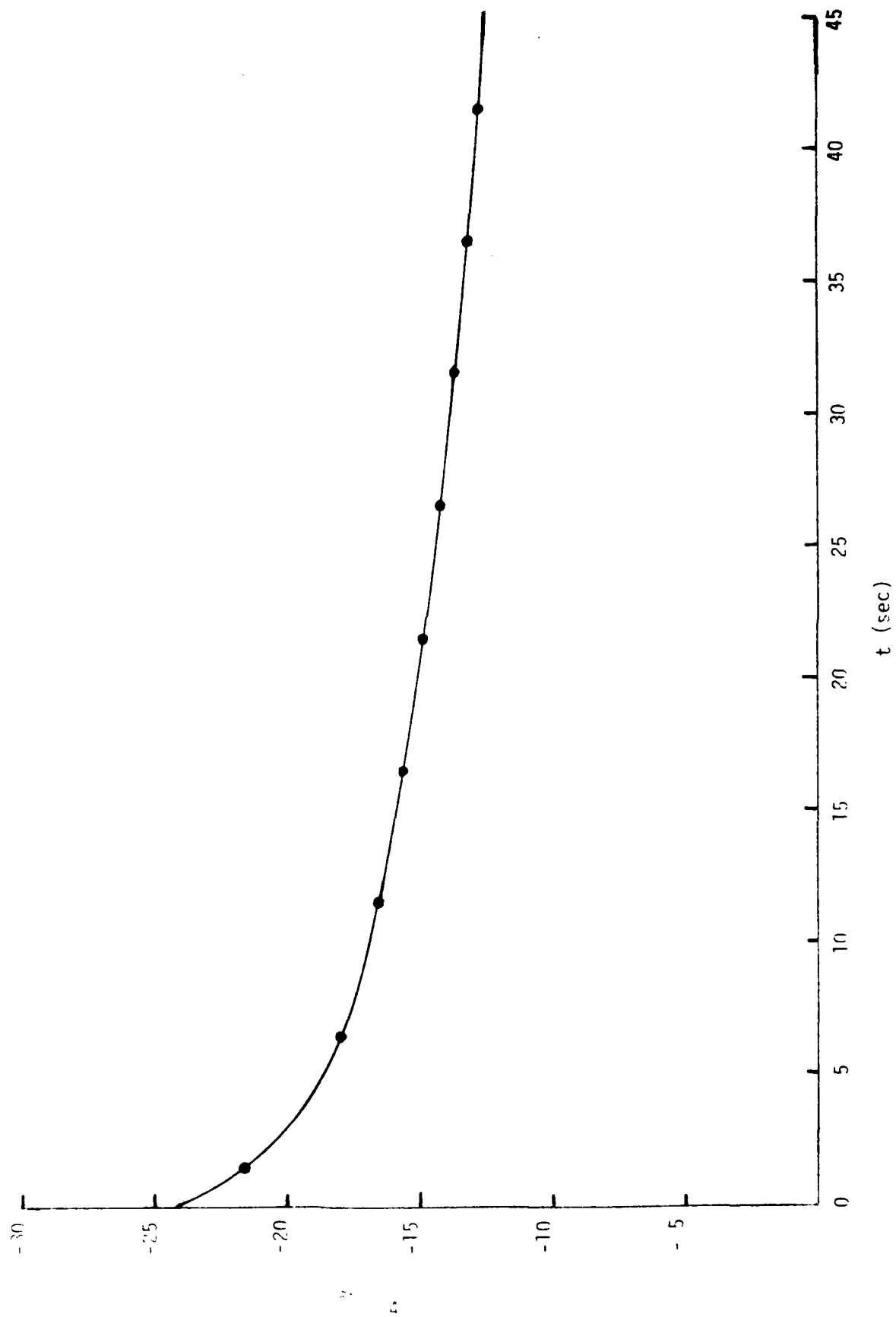


TABLE 1  
Dark Decay Parameters

Ro11 194-1

<u>Sample No.</u>	<u>V<sub>0</sub></u>	<u>A</u>	<u>B</u>	<u>δ</u>
18	23.57	3.19 x 10 <sup>7</sup>	-4.99	8.84 x 10 <sup>-2</sup>
19	24.04	2.06 x 10 <sup>7</sup>	-4.87	6.36 x 10 <sup>-2</sup>
22	20.65	1.86 x 10 <sup>7</sup>	-5.09	9.71 x 10 <sup>-2</sup>
23	21.13	1.24 x 10 <sup>7</sup>	-4.90	8.27 x 10 <sup>-2</sup>
24	21.21	6.48 x 10 <sup>6</sup>	-4.63	1.17 x 10 <sup>-1</sup>
25	21.36	1.62 x 10 <sup>7</sup>	-5.00	7.90 x 10 <sup>-2</sup>
26	21.68	1.05 x 10 <sup>7</sup>	-4.81	7.14 x 10 <sup>-2</sup>
27	21.39	1.14 x 10 <sup>7</sup>	-4.83	9.57 x 10 <sup>-2</sup>
28	21.74	1.76 x 10 <sup>7</sup>	-5.00	1.21 x 10 <sup>-1</sup>
29	21.58	2.67 x 10 <sup>7</sup>	-5.18	6.33 x 10 <sup>-2</sup>
30	21.91	7.41 x 10 <sup>6</sup>	-4.68	8.07 x 10 <sup>-2</sup>
31	21.37	9.47 x 10 <sup>6</sup>	-4.85	1.05 x 10 <sup>-1</sup>
32	21.25	5.30 x 10 <sup>6</sup>	-4.62	6.83 x 10 <sup>-2</sup>
Mean:		1.50 x 10 <sup>7</sup>	4.88	8 x 10 <sup>-2</sup> (0.17 3.5%)

$$t - t_0 = A (V^B - V_0^B)$$

### 3.1.2 Voltage-Log E and Spectral Responses of KC-Film

With the aid of the manual precision imaging system, KC-Film was charged and imaged using a calibrated grey scale step wedge, and the V-log E response of the material was obtained. The light source used was a xenon flash lamp calibrated using an EG&G spectroradiometer Model 585 with a Model 585-11 monochromator housing and a Model 350-800 quartz fiber optic probe. The radiation was filtered using a Melles GR10T 2179/3700 heat reflecting mirror with a Wratten 80D filter to simulate 5500°K daylight. A typical voltage vs. log E curve for film 194-1 is shown in Figure 2. Exposures were made approximately 8 seconds after charging. In addition, a spectral response curve for KC-101 material is shown in Figure 3.

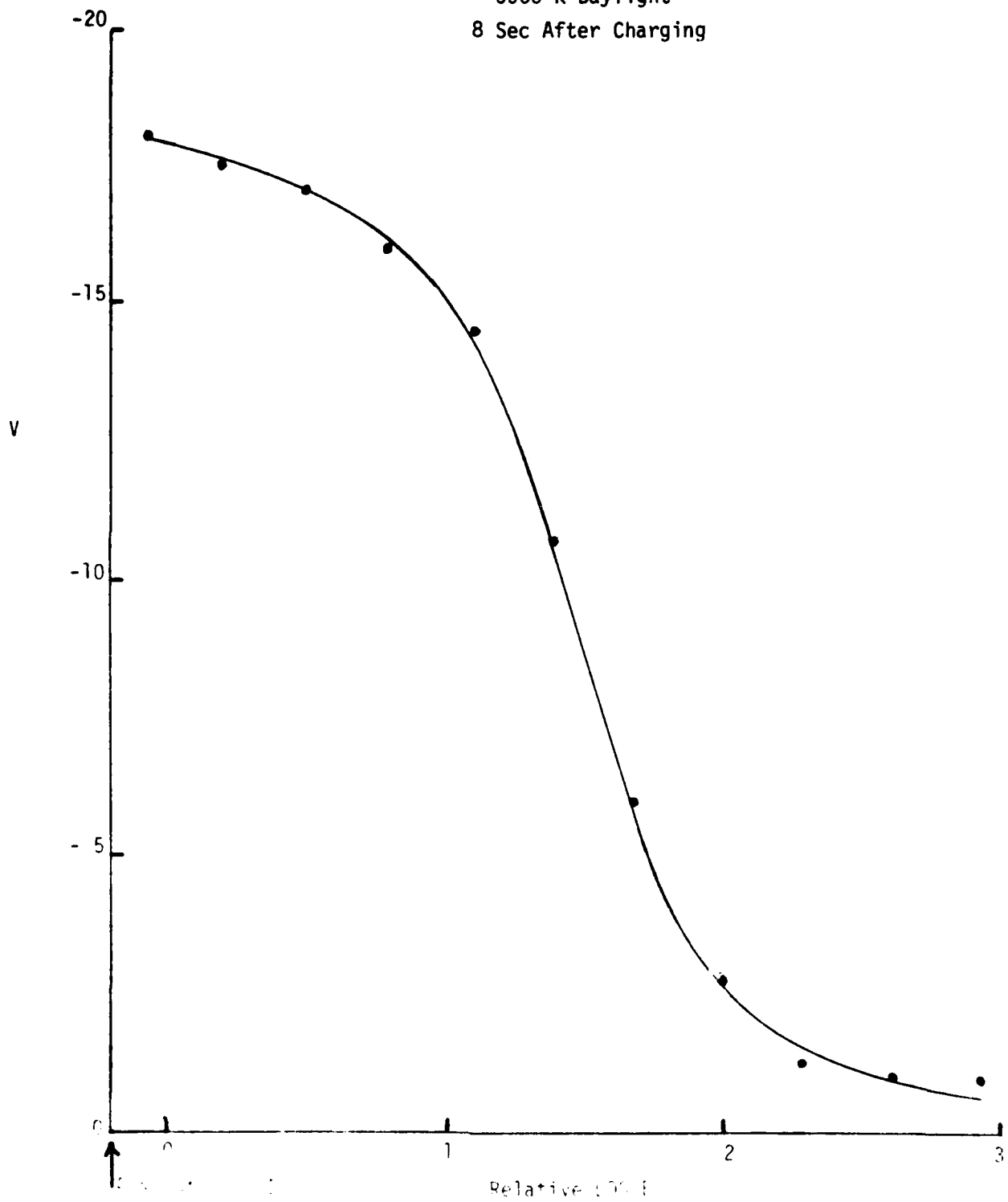
### 3.1.3 Reciprocity

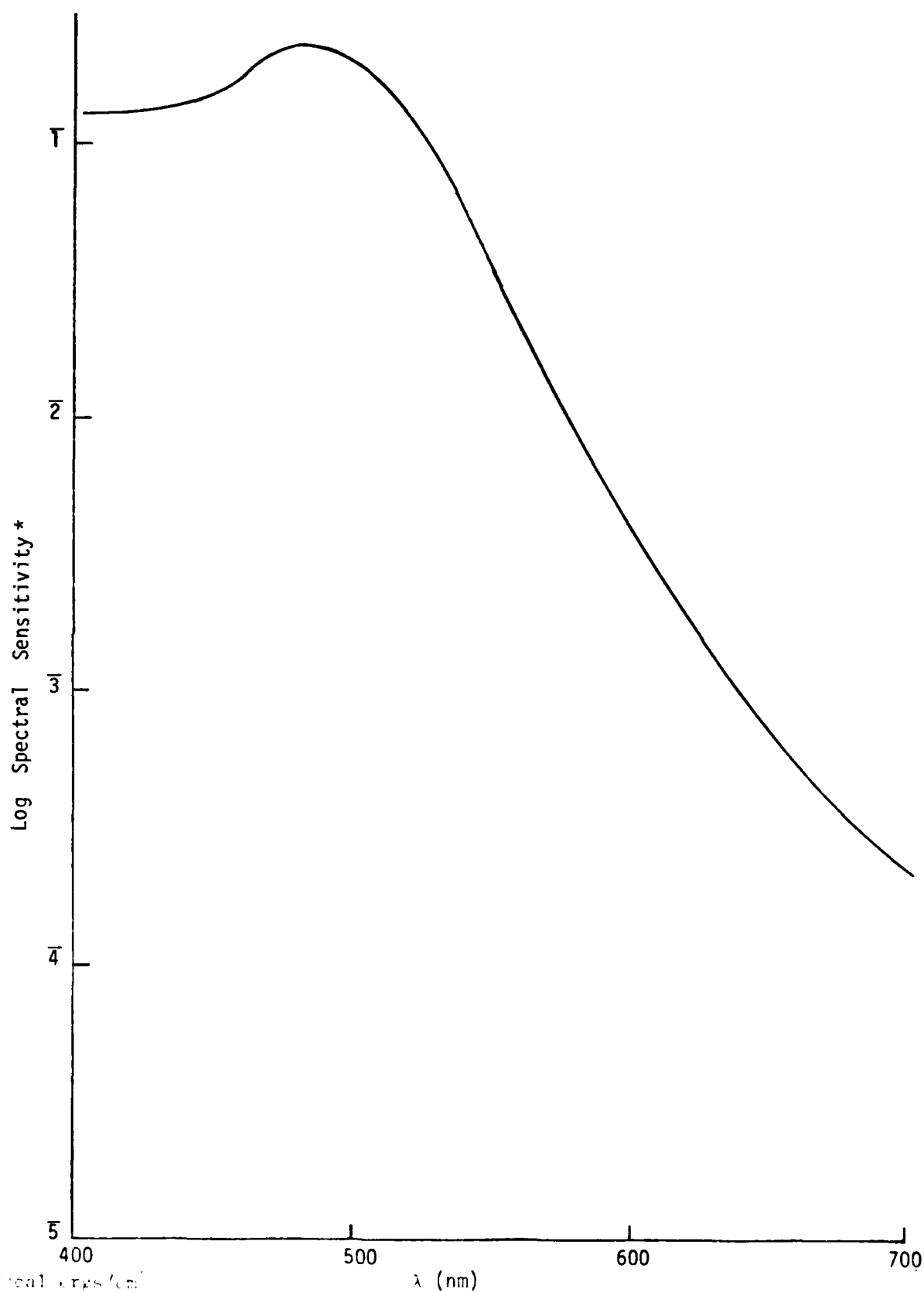
The reciprocity failure of KC-Film was determined. The exposure required to discharge KC-Film to half voltage was measured using exposure times of 1  $\mu$ sec to 1 sec in six increments approximately equally spaced. The maximum change in exposure required is less than a factor of two (one stop).

### 3.2 Density as a Function of Toning Time at Fixed Surface Voltage

Film samples were charged and toned on the 39-B system; toners CR-42 and CR-53 were used, each at three concentrations: 50, 100 and 200 gm/kg. Films were charged with a corona current of 65  $\mu$ A and a film travel speed of 60 mm/sec was used. The bias plate was spaced 0.15" from the film and an AC bias of  $\pm 20$ V, 3 Hz was applied to suppress Bénard cell formation. All film samples had a surface voltage of  $\approx -20$ V at the onset of toning. The results of this test series are shown in figures 4 through 9.

Figure 2  
194-1 V-LOG E  
5500°K Daylight  
8 Sec After Charging





\*reciprocal  $\text{ergs/cm}^2$   
for 0.01 lux-sec

Figure 3. Spectral Response Curve for KC-101 Film

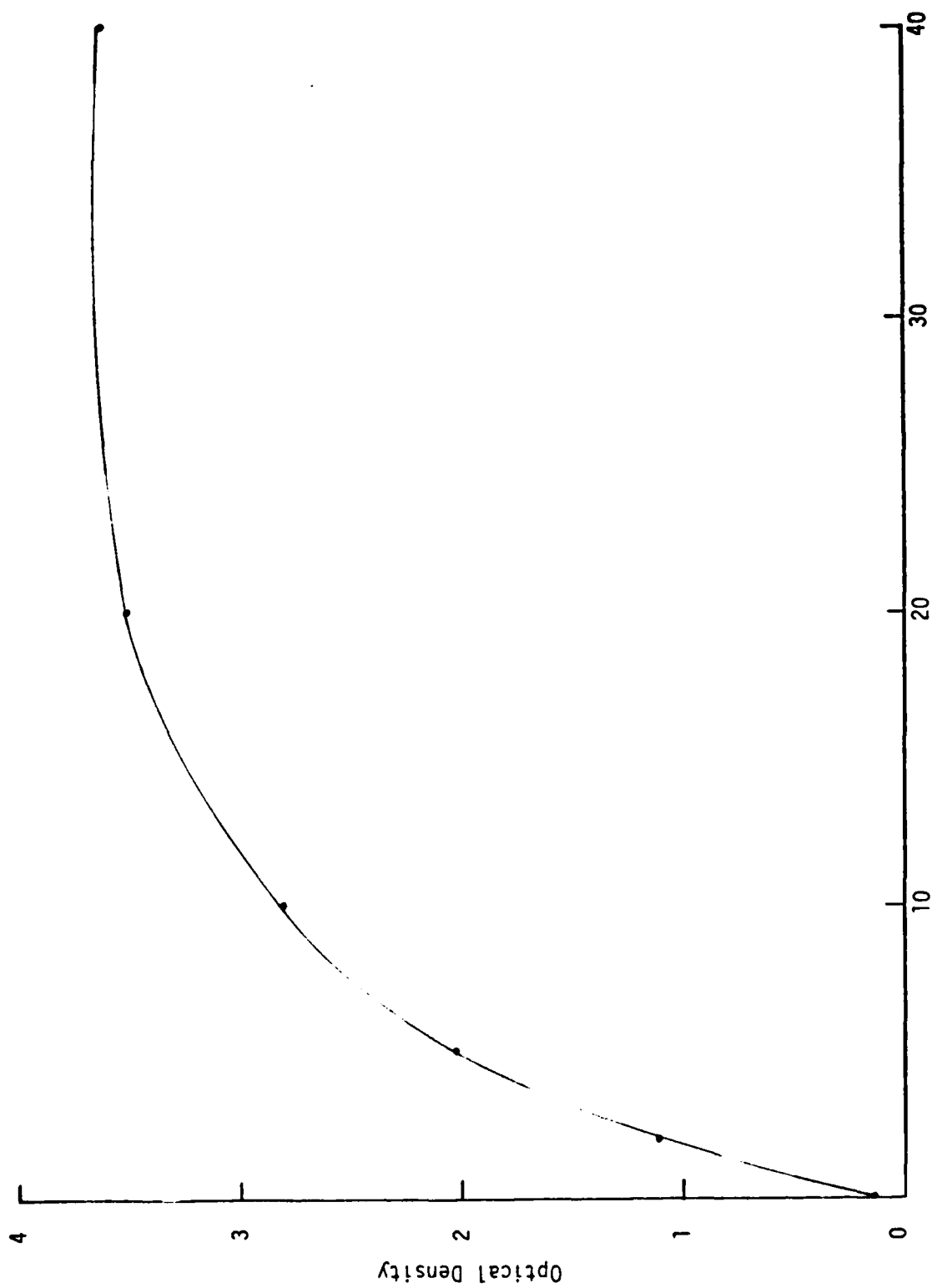


Figure 4. Density Versus Toning Time  
CR-42 50 g/kg

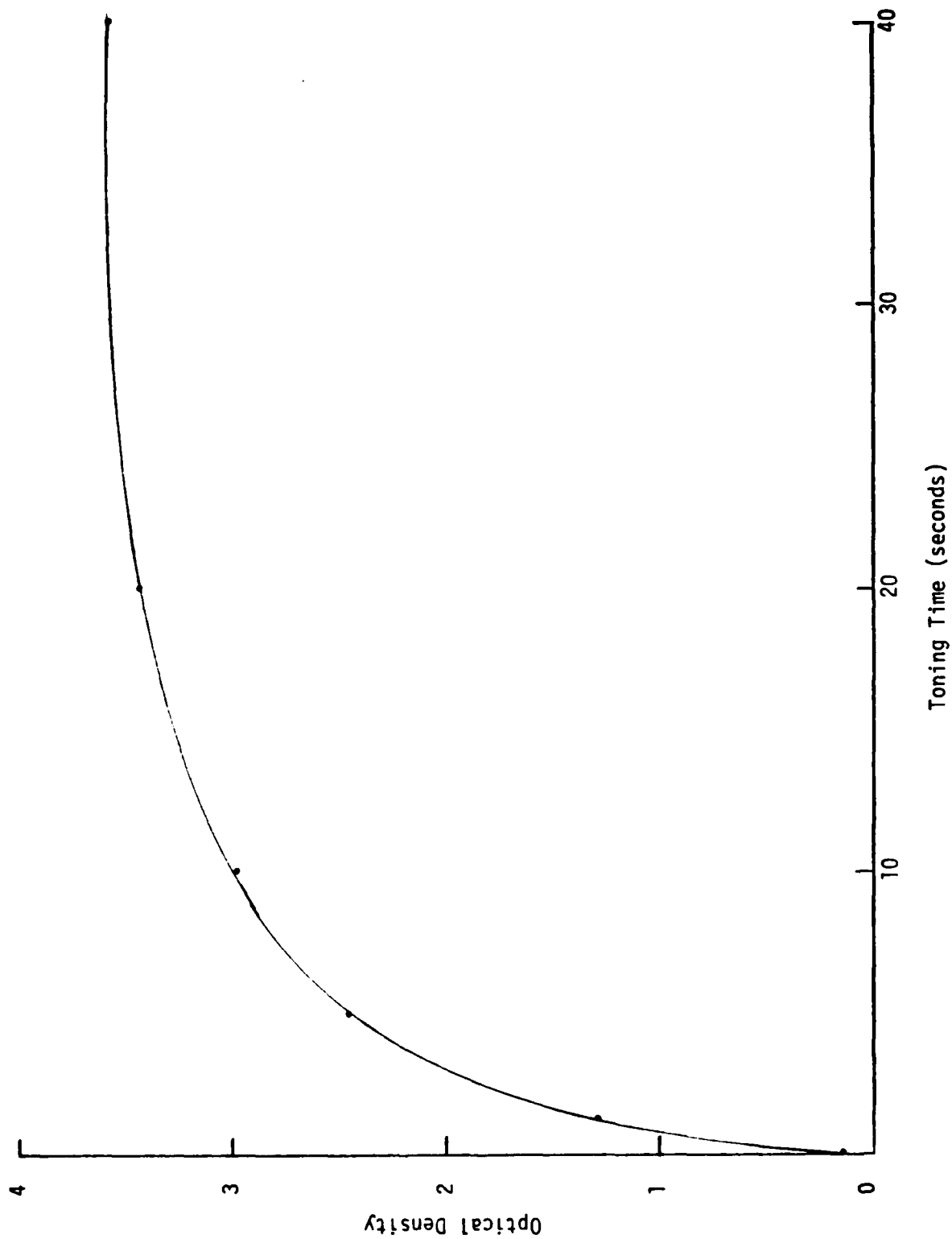


Figure 5. Density Versus Toning Time  
CR-42 100 g/kg

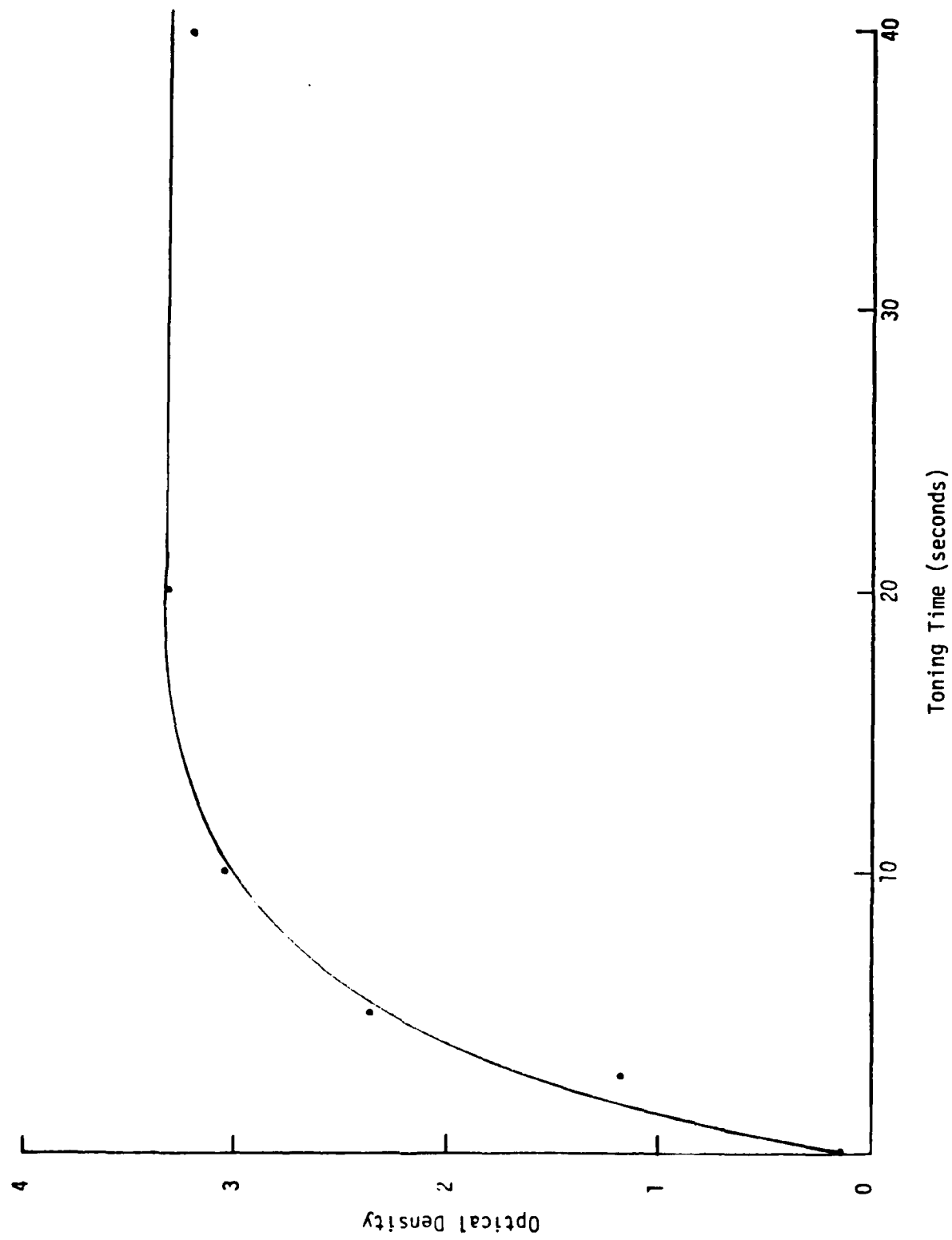


Figure 6. Density Versus Toning Time  
CR-42 200 g/kg

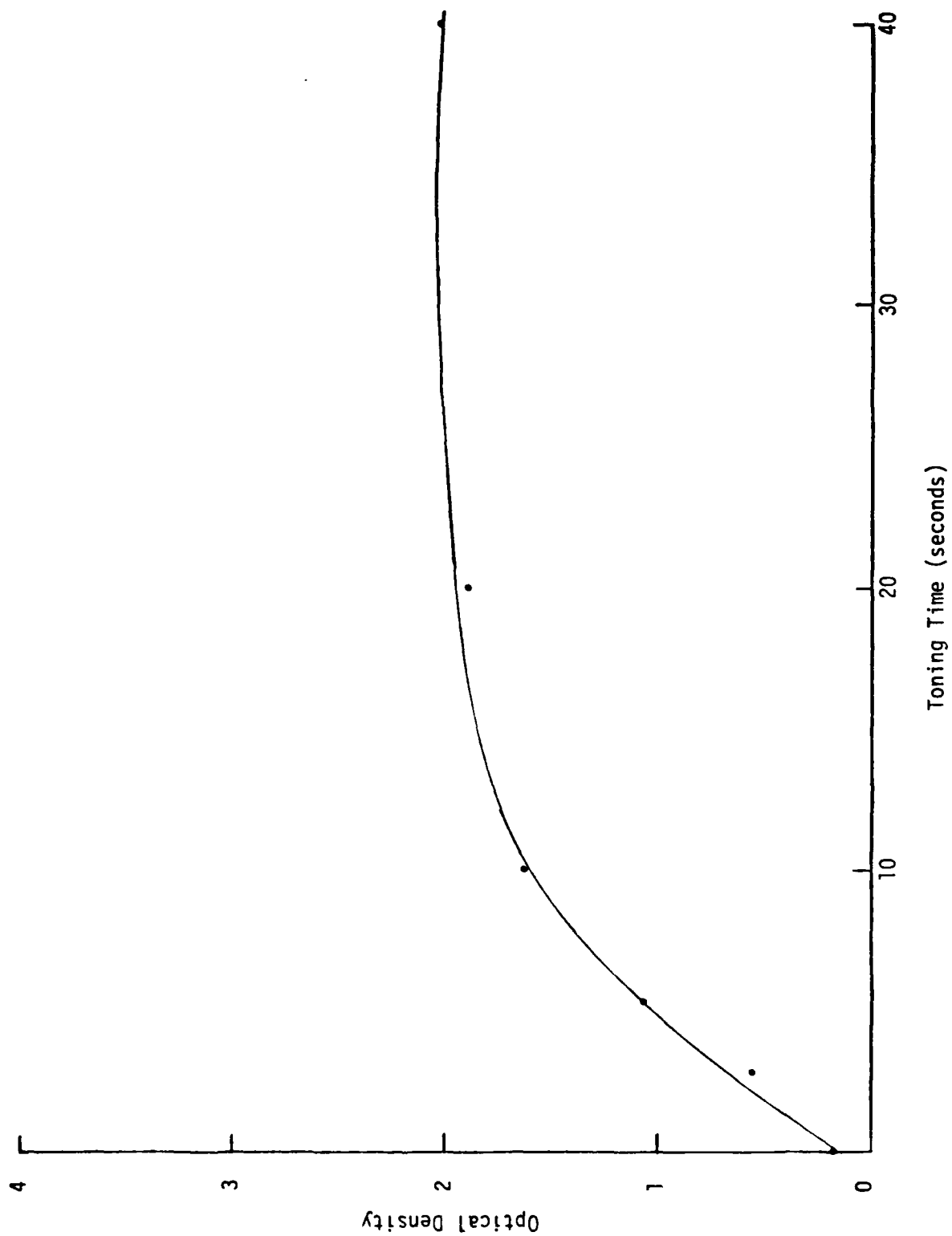


Figure 7. Density Versus Toning Time  
CR-53 50 g/kg

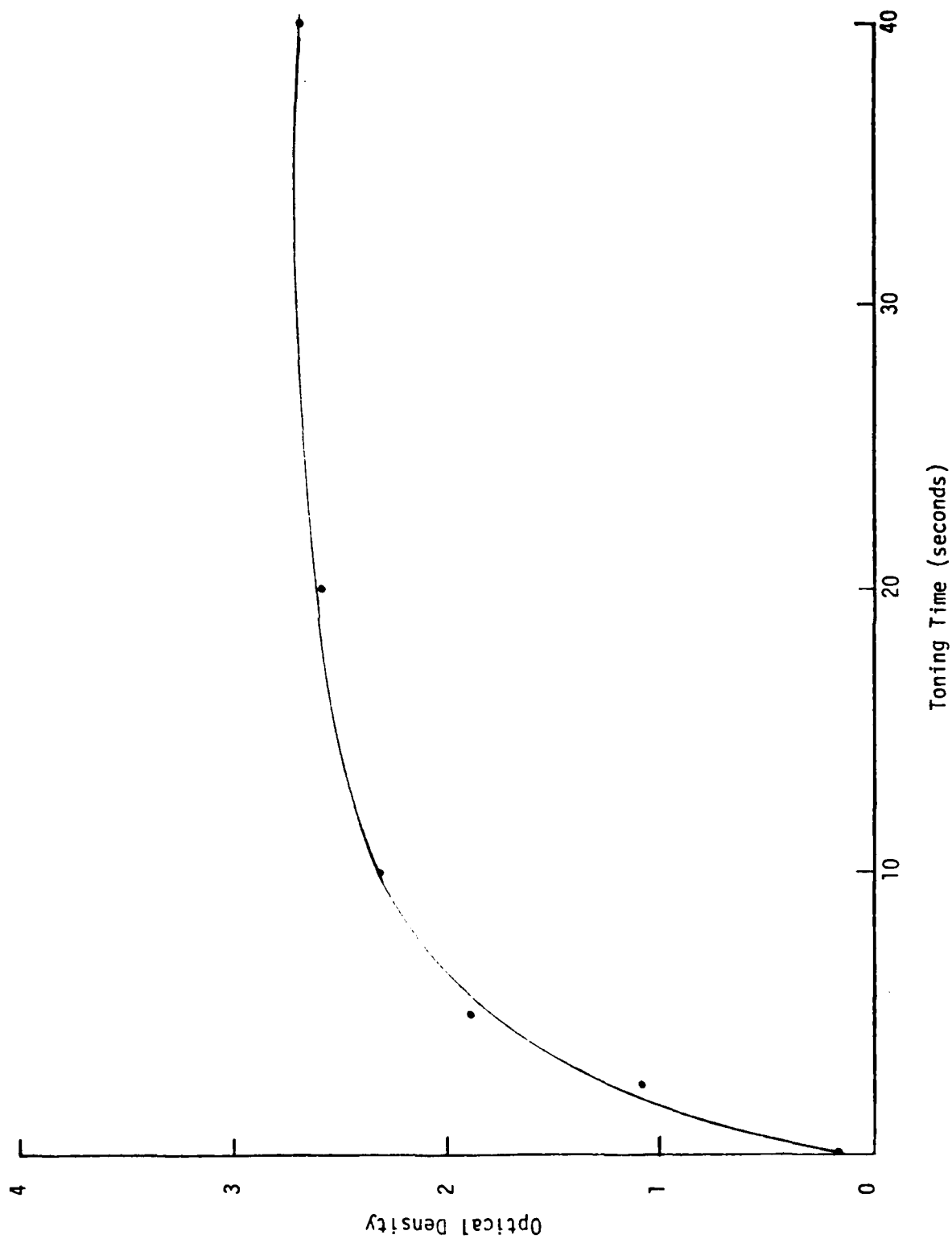


Figure 8. Density Versus Toning Time  
CR-53 100 g/kg

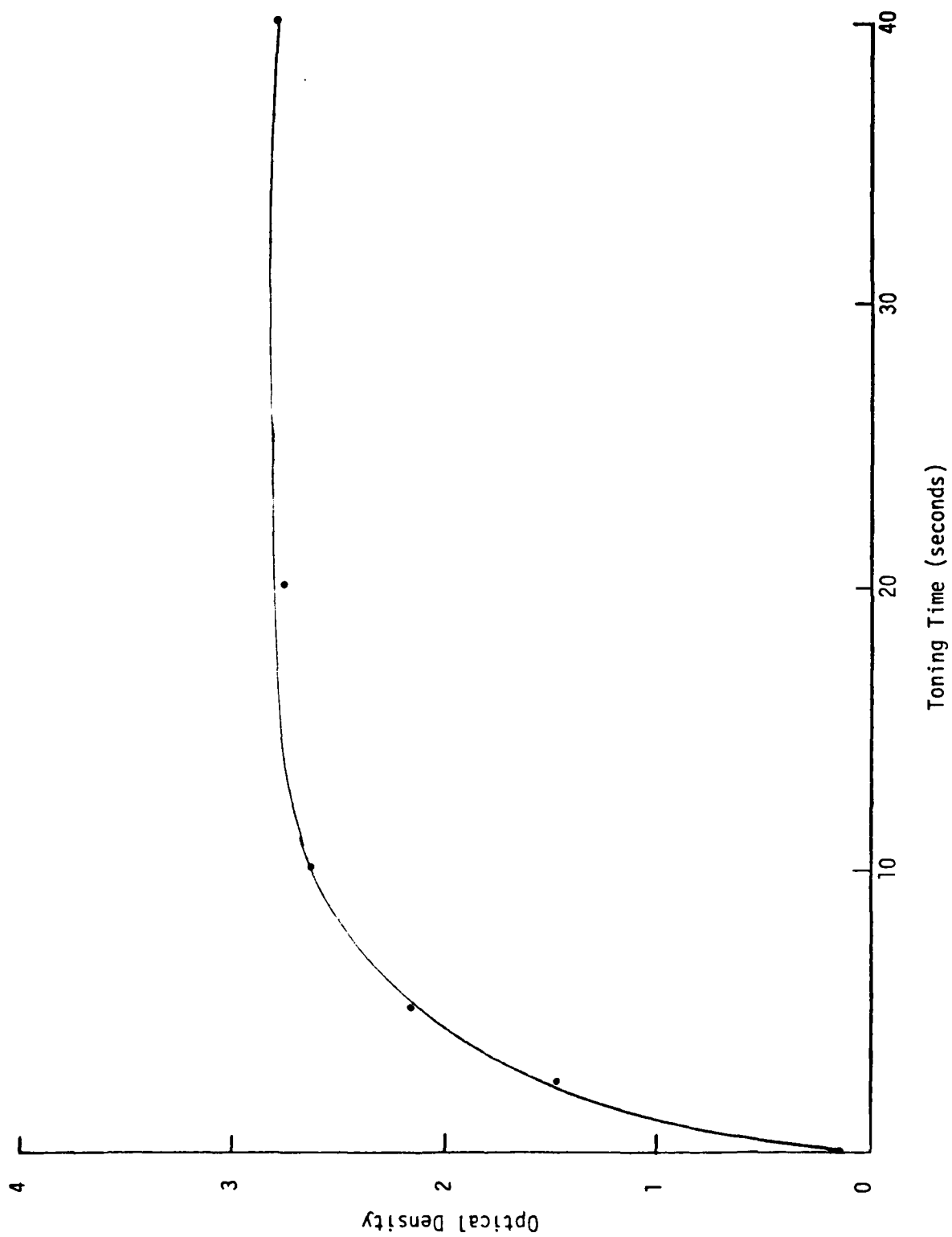


Figure 9. Density Versus Toning Time  
CR-53 200 g/kg

### 3.3 Density as a Function of Surface Voltage at Fixed Toning Time

The same two toners were used as before: CR-42 and CR-53, at the same working concentrations of 50, 100, and 200 gm/kg. The process parameters as outlined in Section 3.2 were once again employed for the generation of all film samples. All films were toned for 5 seconds. The results of this test series are shown in figures 10 through 15.

### 3.4 Density Uniformity CR-42 and CR-53

The manual precision imaging system was used for this determination. Films were dark decayed to various voltages to provide appropriate levels of transmission density. The film samples were marked into a grid comprised of 1/2 inch squares, 5 across and 4 down. This provided 20 areas for density measurement. Densities were measured in the center of each square using a 2 mm aperture. A Macbeth TD 518 densitometer was used and was calibrated against a step wedge of known density, traceable to NBS standards. The standard deviation of density is reported in percent of density. The results of these experiments are given in Table 2. As would be expected, there is some indication of increased variability at densities below 1.0 because below this density the densitometer errors become progressively more serious. The overall density variability for all samples is 2.7%, including densitometer error.

### 3.5 Gamma Range for CR-42 and CR-53 Toners

The manual precision imaging system was again used for this series of experiments. Films were charged, dark decayed to the desired voltage, and exposed through a calibrated step wedge. The films were then toned for the

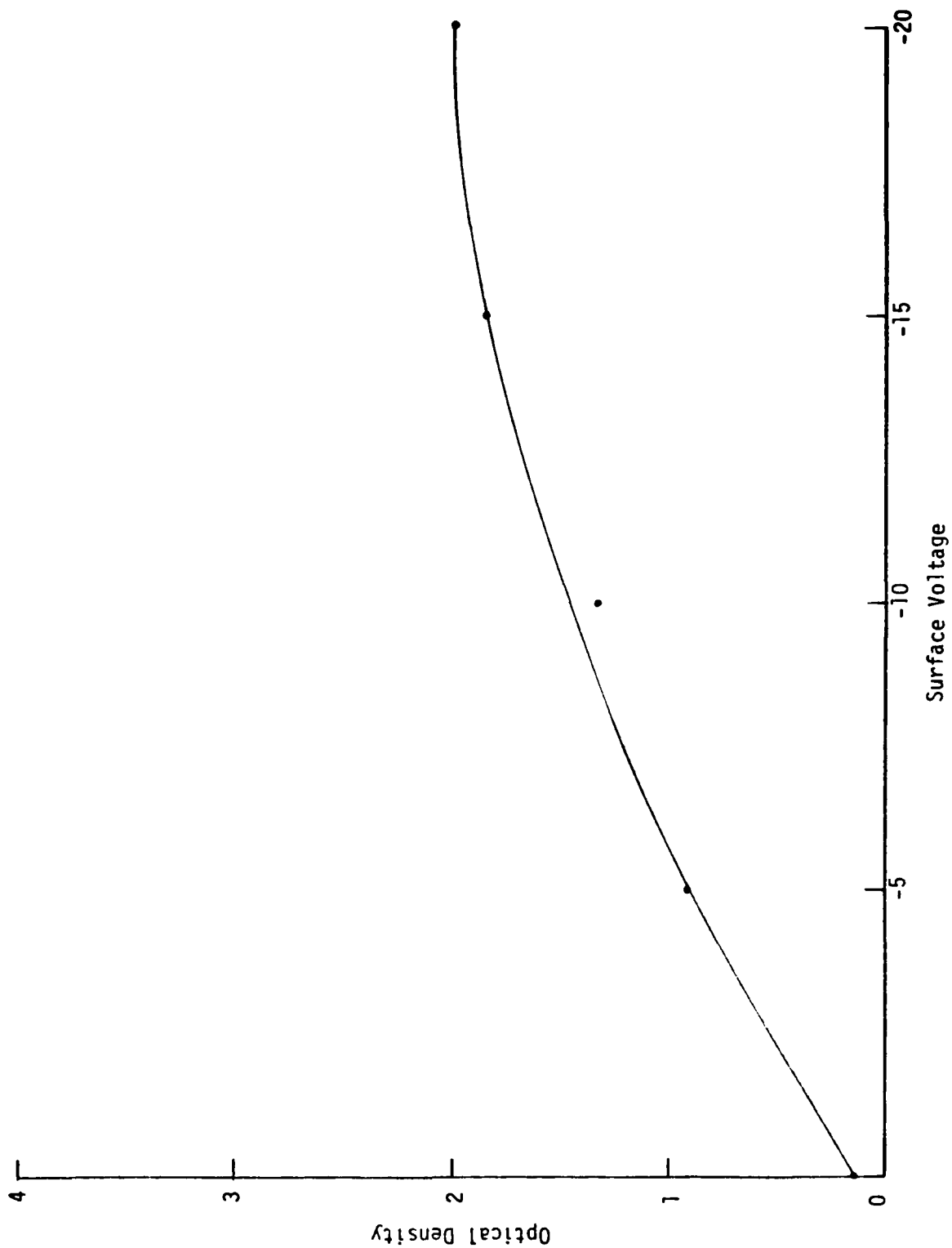


Figure 10. Density Versus Surface Voltage  
CR-42 50 g/kg

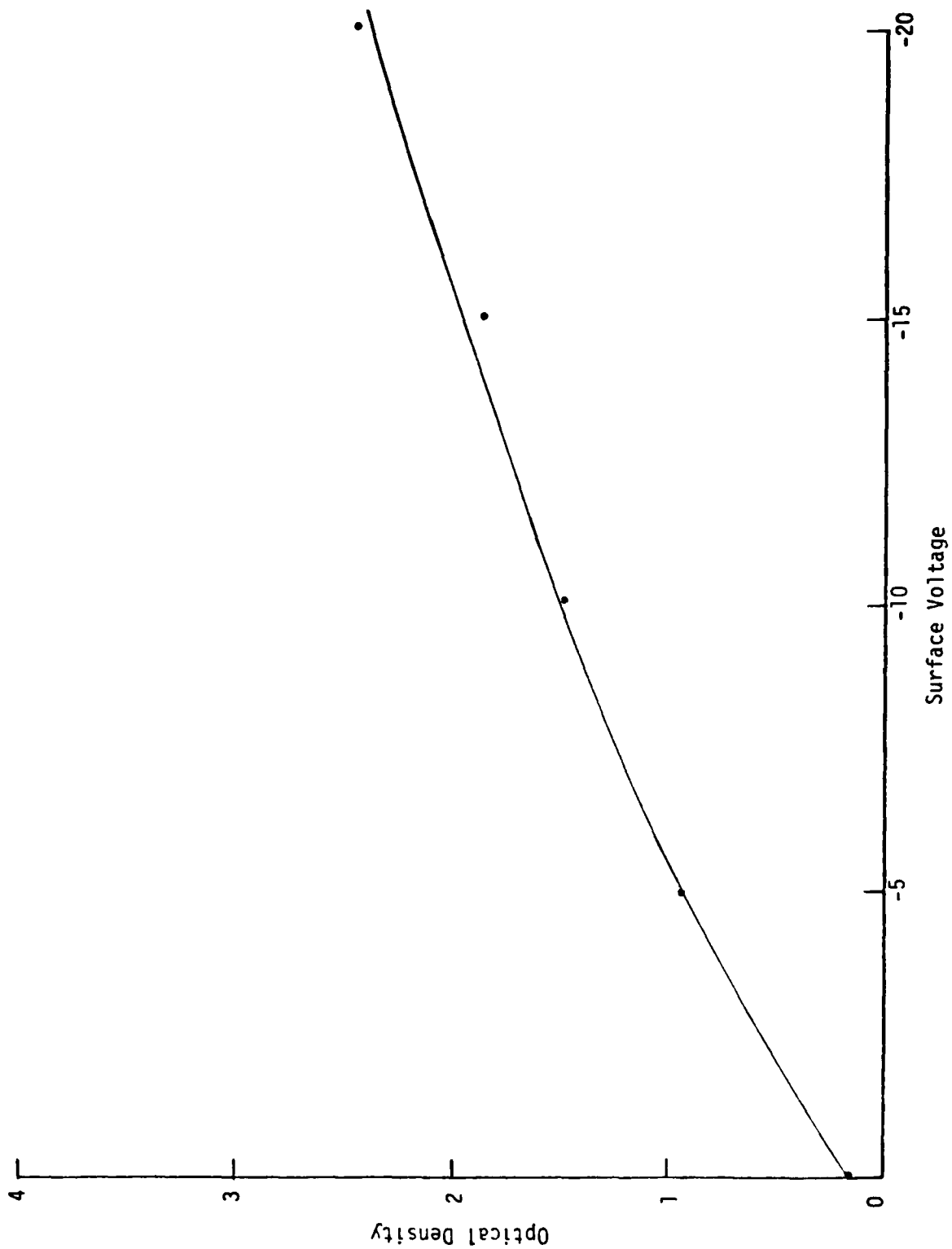


Figure 11. Density Versus Surface Voltage  
CR-42 100 g/kg

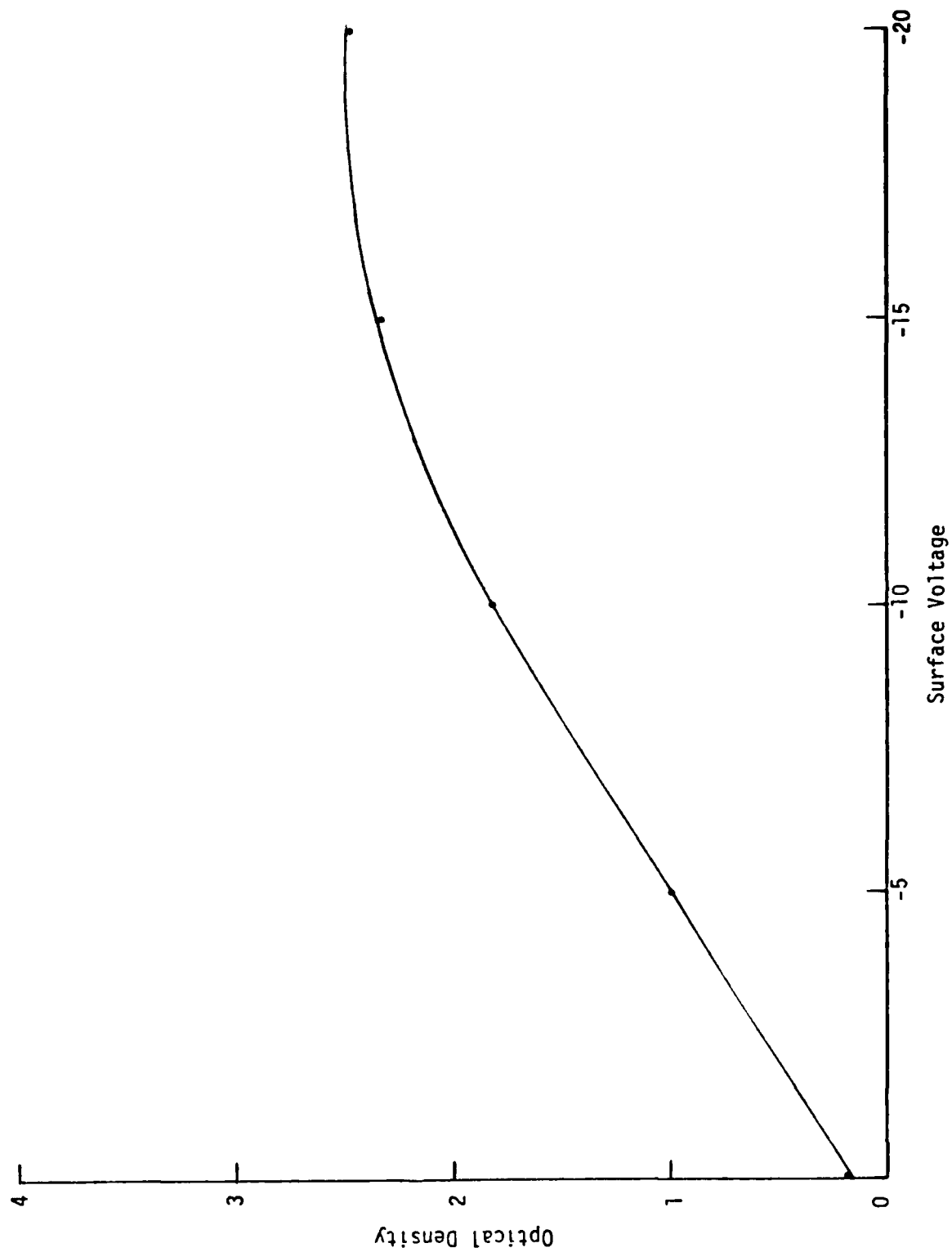


Figure 12. Density Versus Surface Voltage  
CR-42 200 g/kg

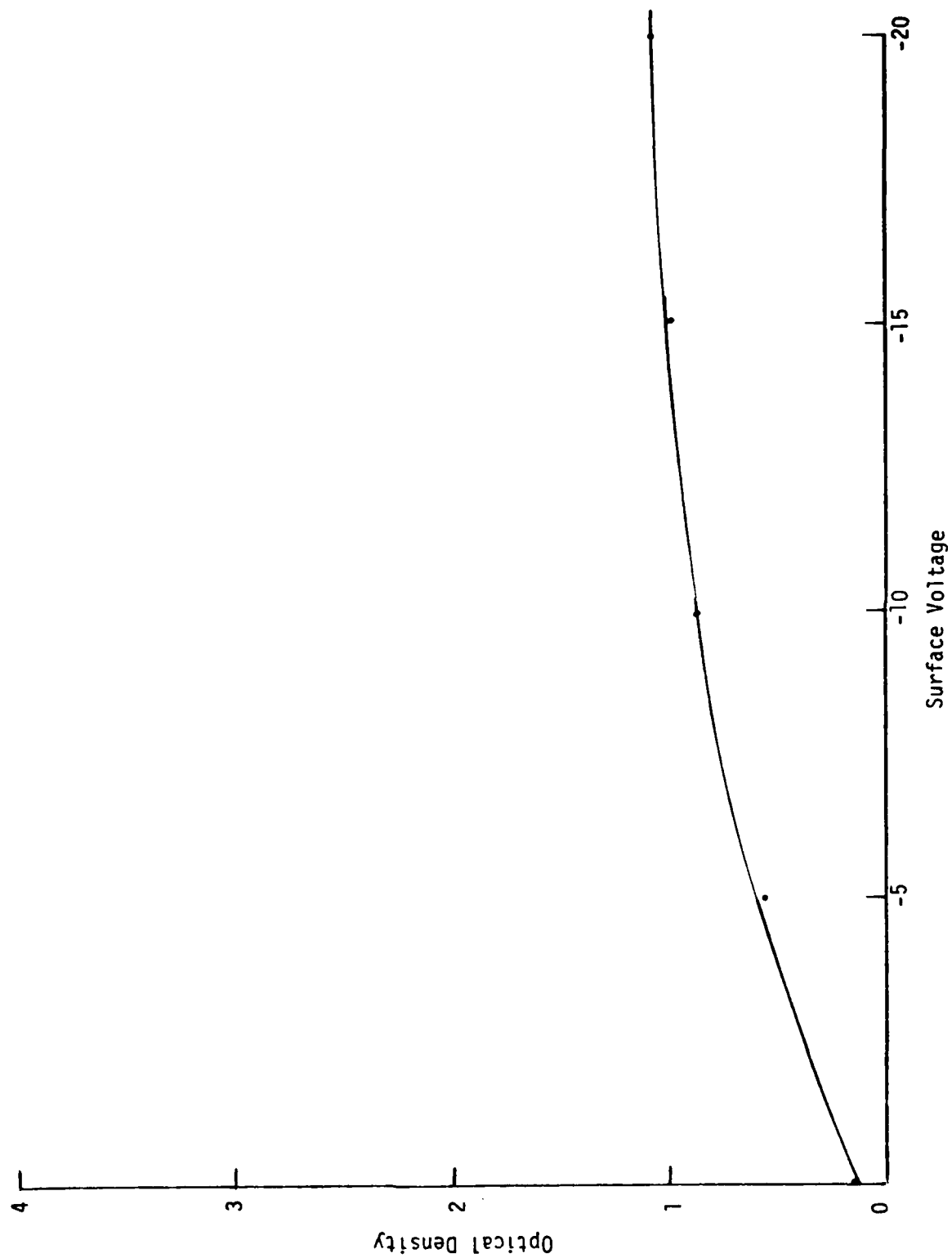


Figure 13. Density Versus Surface Voltage  
CR-53 50 g/kg

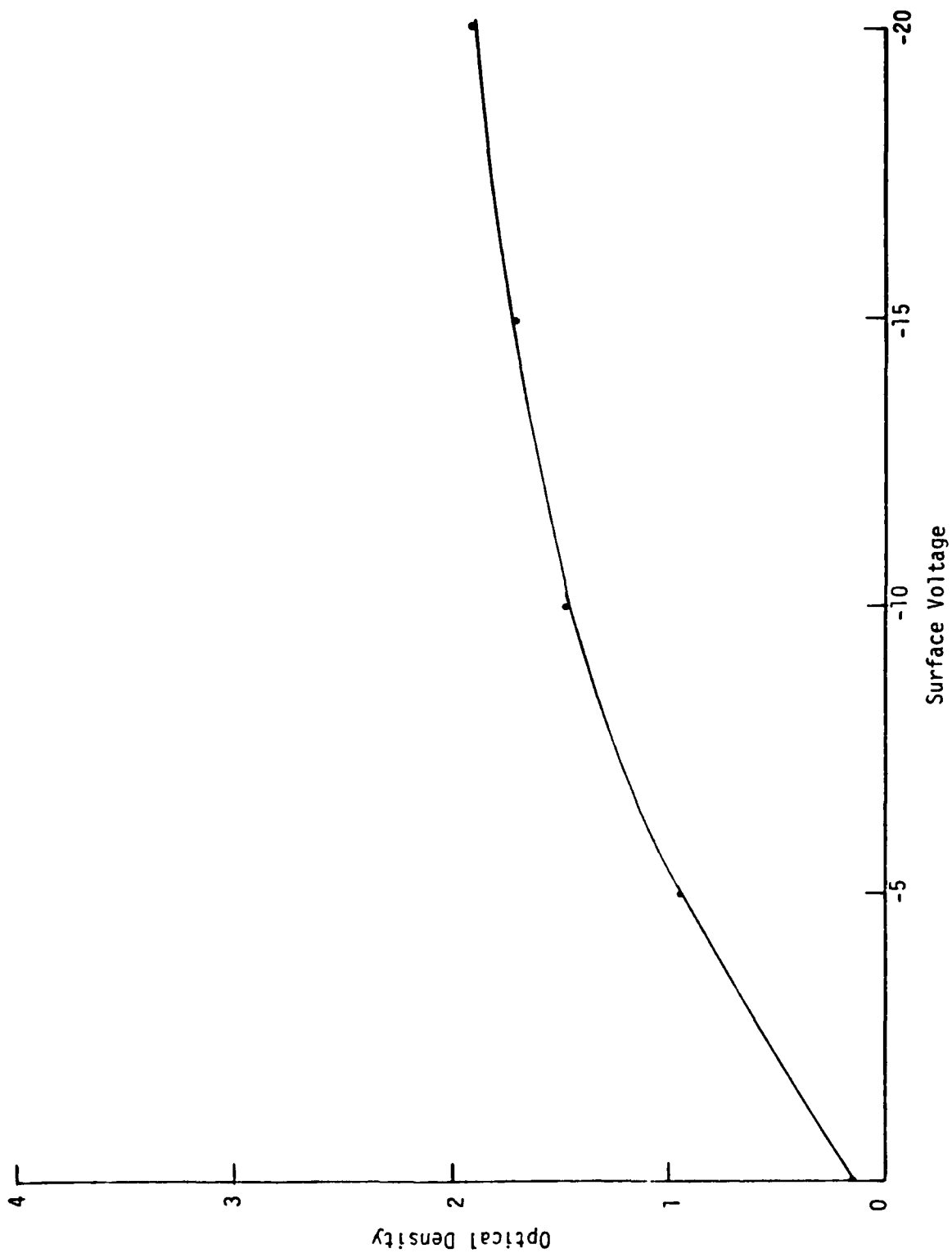


Figure 14. Density Versus Surface Voltage  
CR-53 100 g/kg

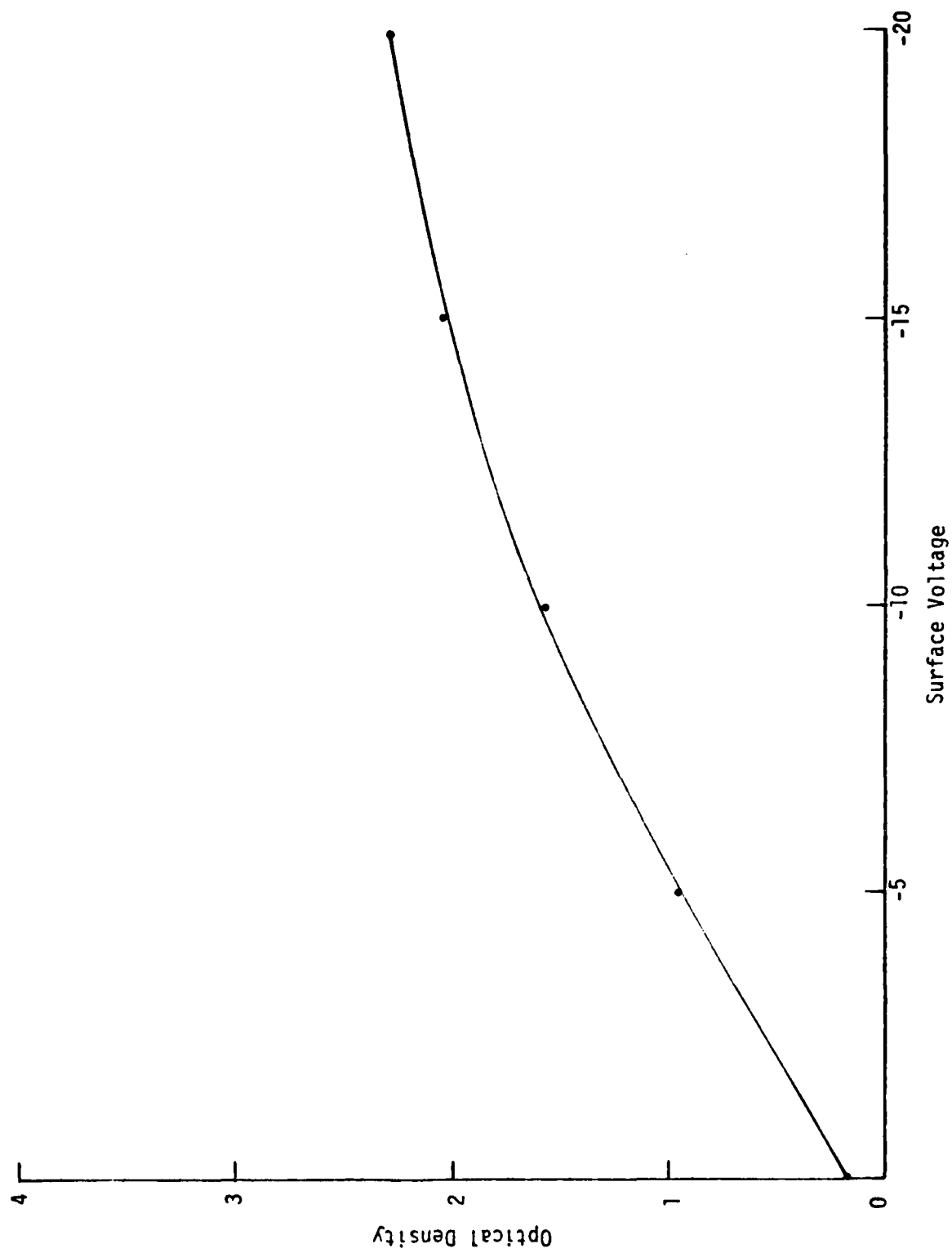


Figure 15. Density Versus Surface Voltage  
CR-53 200 g/kg

TABLE 2

Density Uniformity

CR-42 Toner

CR-53 Toner

50 gm/kg

50 gm/kg

<u>Density</u>	<u><math>\delta</math> as % of Density</u>	<u>Density</u>	<u><math>\delta</math> as % of Density</u>
2.63	1.6	1.88	6.0
1.72	3.9	1.46	2.9
1.62	1.9	1.45	2.6
1.36	1.4	0.99	1.6
0.84	3.7	0.62	1.9

100 gm/kg

100 gm/kg

<u>Density</u>	<u><math>\delta</math> as % of Density</u>	<u>Density</u>	<u><math>\delta</math> as % of Density</u>
2.81	1.0	2.50	3.0
2.21	1.0	2.11	0.7
1.68	3.4	1.11	1.5
1.34	3.7	0.66	1.6
1.01	2.4		
0.78	4.3		

200 gm/kg

200 gm/kg

<u>Density</u>	<u><math>\delta</math> as % of Density</u>	<u>Density</u>	<u><math>\delta</math> as % of Density</u>
2.13	1.7	2.55	2.6
1.54	1.8	1.79	1.7
1.21	2.9		
1.08	2.1		
0.81	1.6		

required length of time. Table 3 presents the responses in terms of  $D_{\max}$ ,  $D_{\min}$  and  $\gamma$  for toner CR-42. The characteristic curves for CR-42 are shown in figures 16 through 24. The manual precision imaging system is identified on the curves as "Bogen II." Similar responses for toner CR-53 are shown in Table 4 and figures 25 through 33.

### 3.6 Resolving Power Versus Toner Concentration for CR-42 and CR-53 Toners at Constant Surface Voltage

The manual precision imaging system was used for this series of tests. An evaporated 30 element multi-density target was used. This target permits imaging of fifteen resolution targets at constant exposure and varying contrast, as well as fifteen targets at constant contrast and varying exposure. All targets are of the 10/1 length width ratio and include spatial frequencies from 10 through 500 cycles/mm. The targets were contact exposed onto the charged KC-Film. Two exposures were used for each condition as indicated on the abscissas. In all cases, the films were exposed and immediately toned at a surface voltage of  $\approx -20$  volts. Both CR-42 and CR-53 were used at 50, 100, and 200 gm/kg. The results are shown in figures 34 through 51 and tables 5 through 8.

### 3.7 Resolving Power as a Function of Surface Voltage for Samples Toned with CR-42 for Constant Time

The manual precision imaging system was again used with the multi-element resolution target in the contact mode as described above. CR-42 toner was used at 50, 100, and 200 gm/kg. Films were exposed and toned immediately at film surface voltages -20, -15, -10, and -5 volts. All samples were toned for 32 seconds. The responses are shown in figures 52 through 66 and tables 7 and 8.

TABLE 3

Gamma Range - CR-42

<u>Toner Conc. (g/kg)</u>	<u>Toning Time (sec)</u>	<u>V</u>	<u>D<sub>max</sub></u>	<u>D<sub>min</sub></u>	<u>γ</u>
50	5	5	0.66	0.12	0.4
50	5	10	0.96	0.12	0.6
50	5	20	1.61	0.12	1.0
50	10	5	0.81	0.11	0.5
50	10	10	1.29	0.11	0.6
50	10	20	2.34	0.13	2.1
50	30	5	0.99	0.11	0.7
50	30	10	1.78	0.13	1.0
50	30	20	3.59	0.14	3.5
100	5	5	0.68	0.14	0.5
100	5	10	0.94	0.14	0.6
100	5	20	1.97	0.14	1.5
100	10	5	0.82	0.14	0.5
100	10	10	1.33	0.14	0.6
100	10	20	2.75	0.14	2.8
100	30	5	1.00	0.15	0.8
100	30	10	1.74	0.15	1.0
100	30	20	3.68	0.16	3.0
200	5	5	0.70	0.16	0.6
200	5	10	0.84	0.16	0.7
200	5	20	1.66	0.16	1.1
200	10	5	0.73	0.16	0.5
200	10	10	1.01	0.16	0.7
200	10	20	2.50	0.17	1.9
200	30	5	0.85	0.17	0.6
200	30	10	1.23	0.17	0.9
200	30	20	2.90	0.19	2.1

CR-42 AP81200W 50 gm/kg

Tone 5 sec.  
AC  $\pm 14$  V 3 Hz  
Rinsed, Bogen II  
Film 194-1 #27

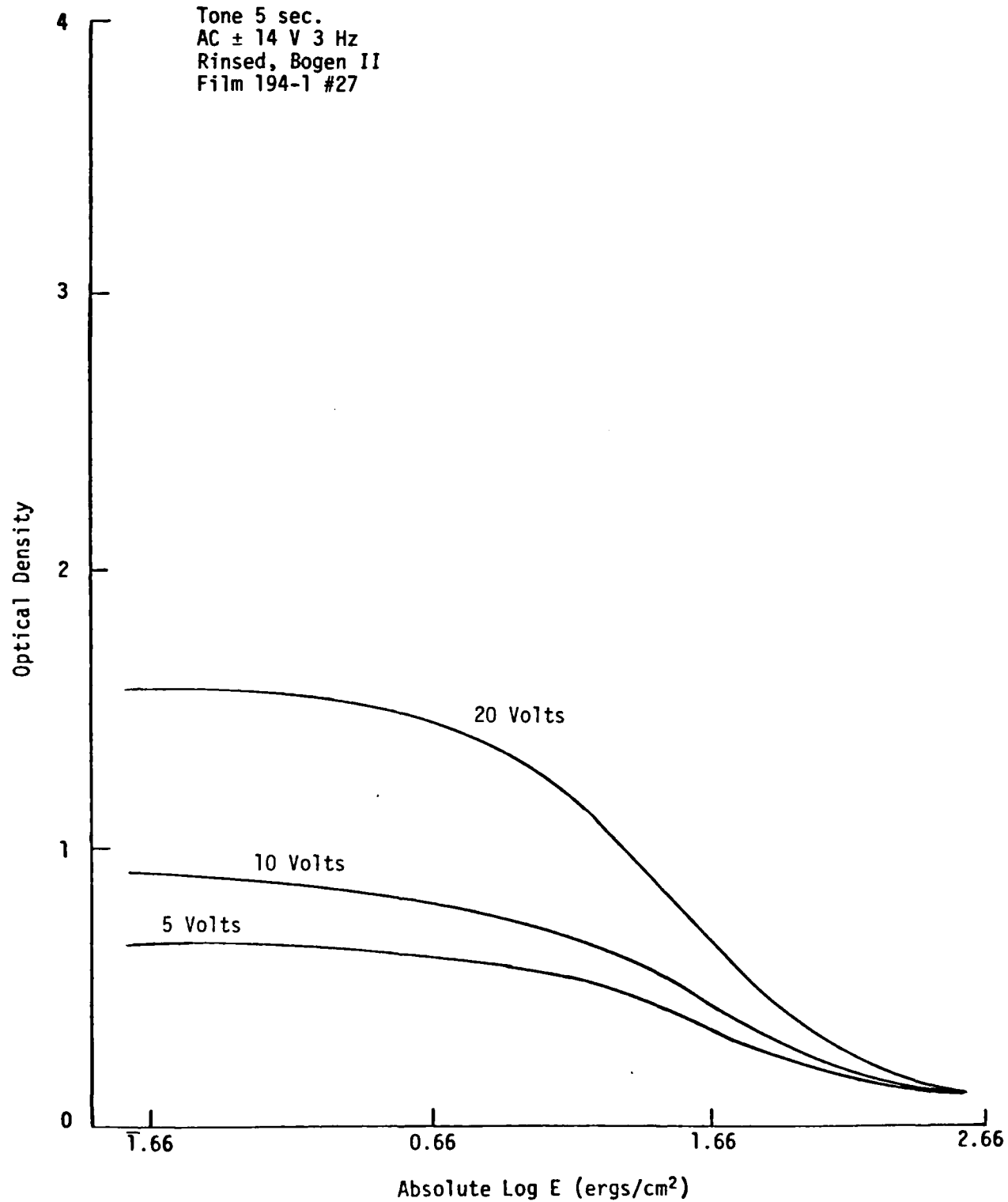


Figure 16. Step Wedge Response to Surface Voltage

CR-42 AP81200W 50 gm/kg

Tone 10 sec.  
AC  $\pm$  14 V 3 Hz  
Rinsed, Bogen II  
Film 194-1 #27

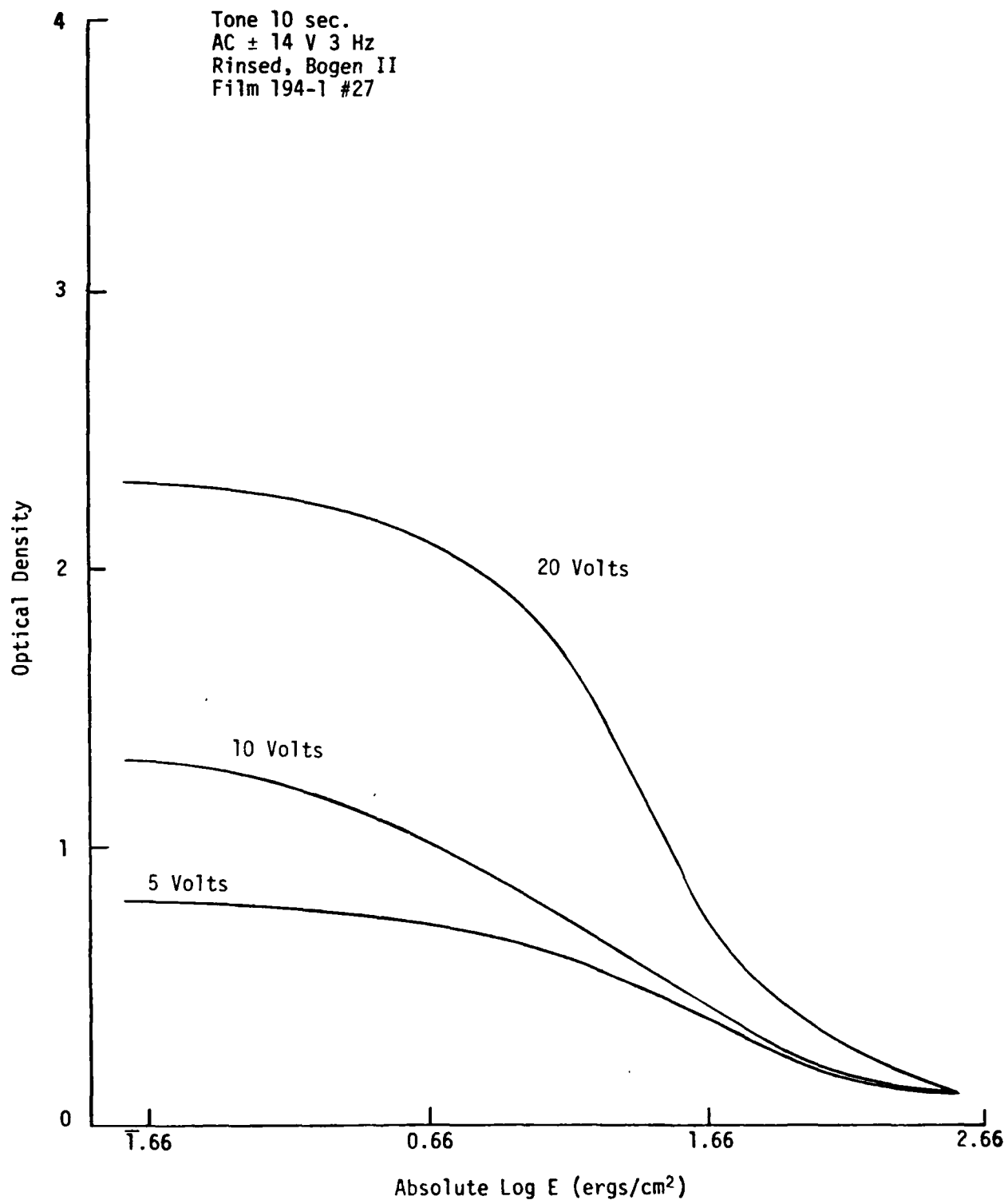


Figure 17. Step Wedge Response to Surface Voltage

CR-42 AP81200W 50 gm/kg

Tone 30 sec.  
AC  $\pm$  14 V 3 Hz  
Rinsed, Bogen II  
Film 194-1 #27

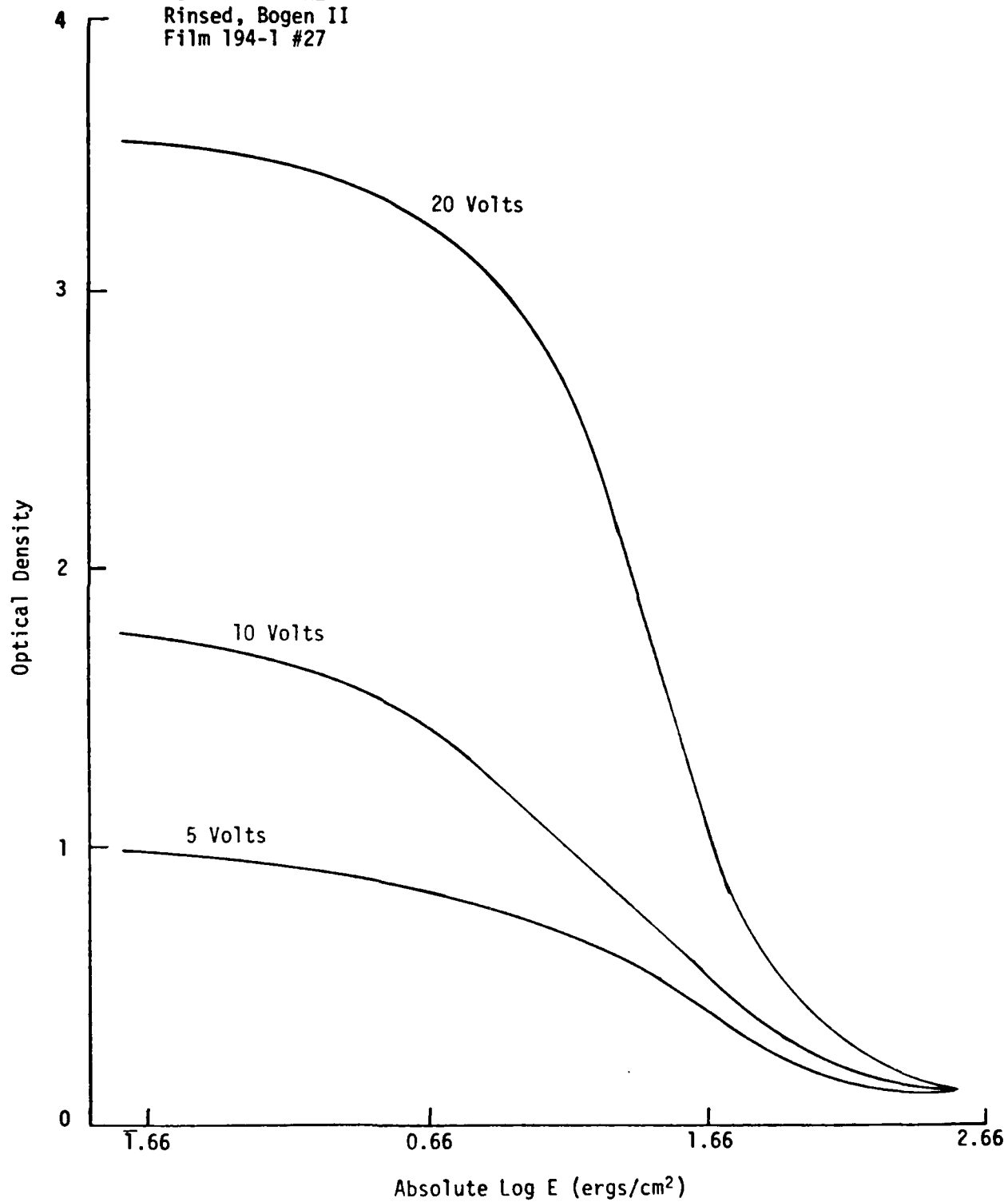


Figure 18. Step Wedge Response to Surface Voltage

CR-42 AP81200W 100 gm/kg

Tone 5 sec.  
AC  $\pm 14$  V 3 Hz  
Rinsed, Bogen II

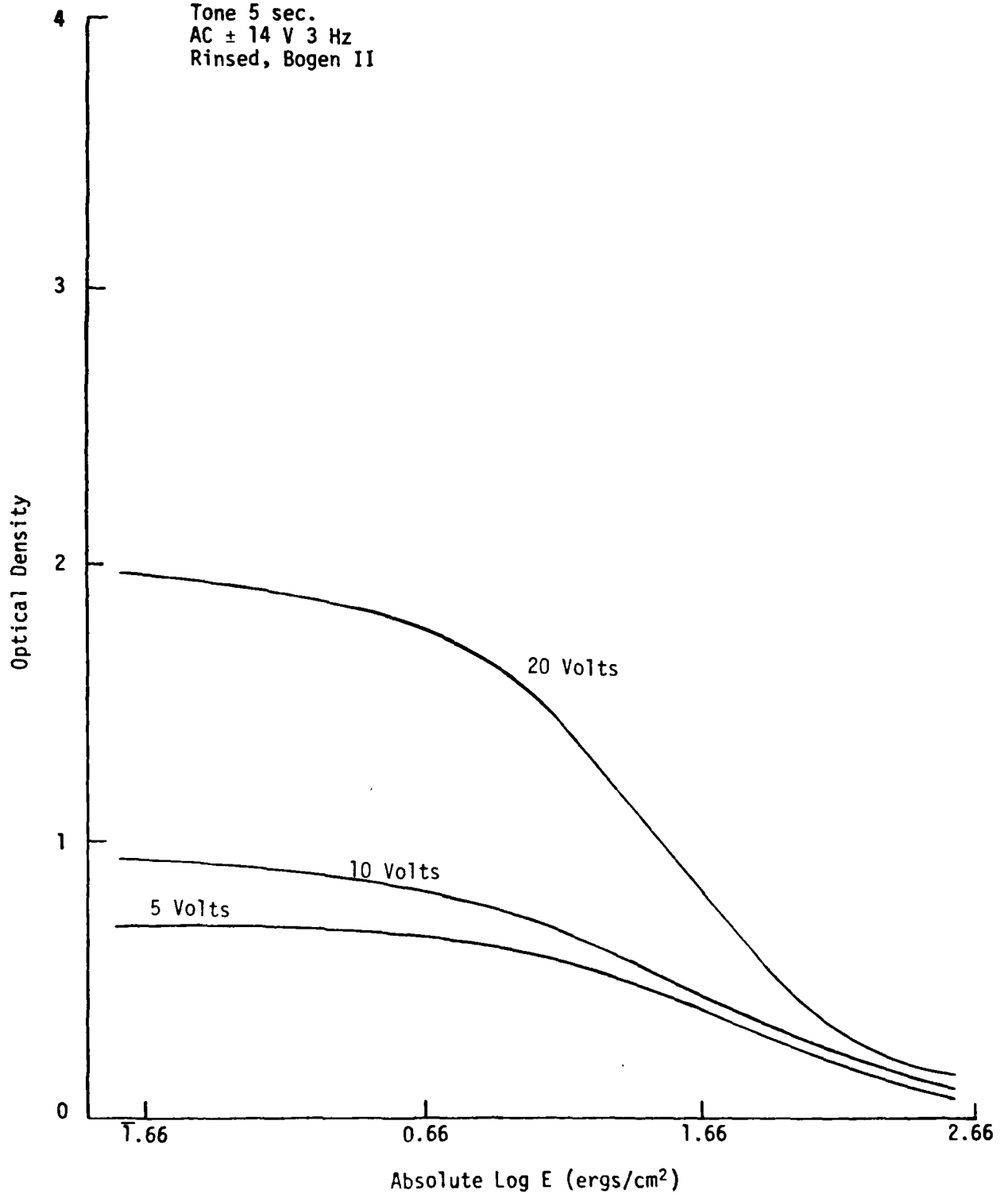


Figure 19. Step Wedge Response to Surface Voltage

CR-42 AP81200W 100 gm/kg

Tone 10 sec.  
AC  $\pm 14$  V 3 Hz  
Rinsed, Bogen II

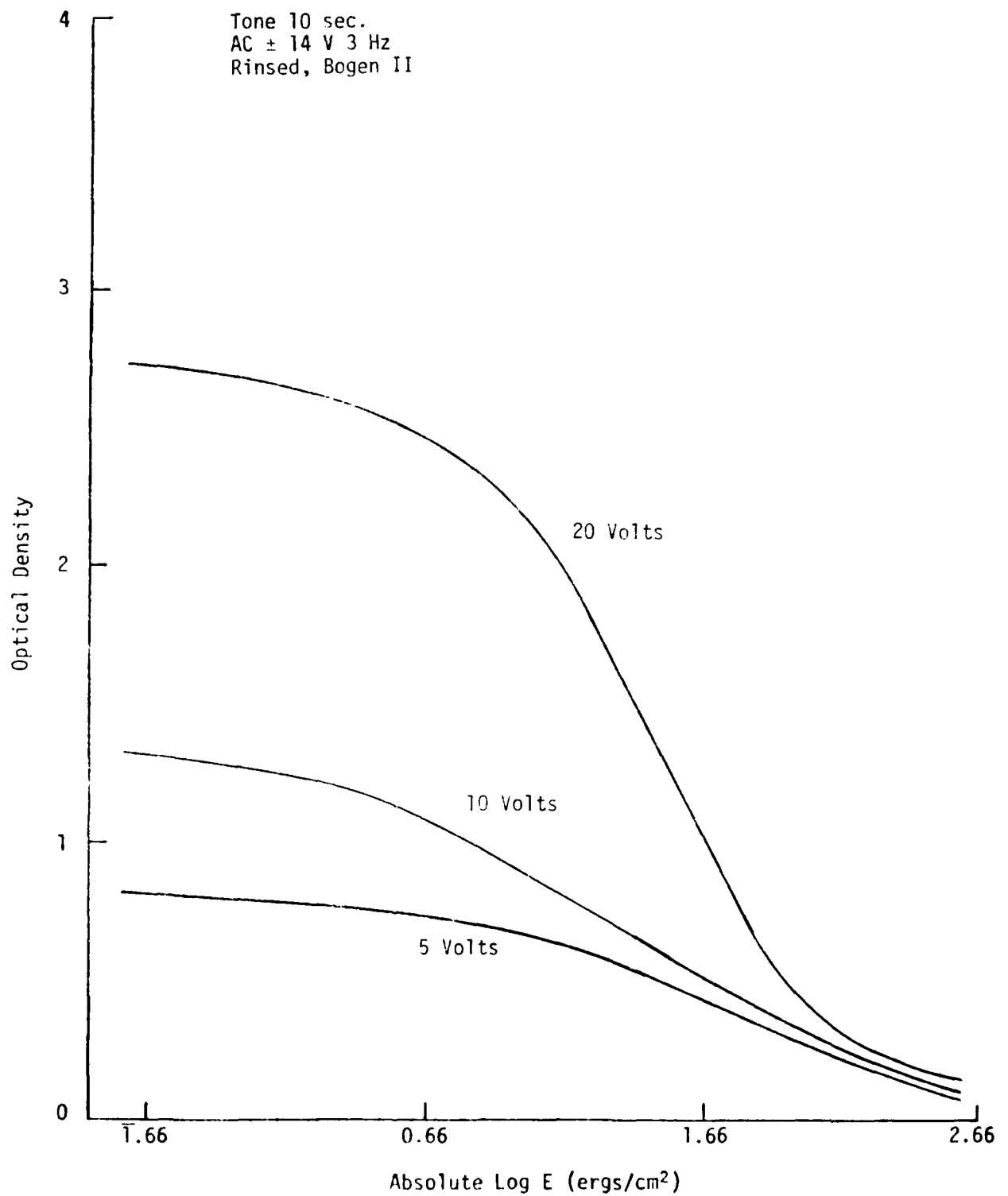


Figure 20. Step Wedge Response to Surface Voltage

CR-42 AP81200W 100 gm/kg

Tone 30 sec.  
AC  $\pm$  14V 3 Hz  
Rinsed, Bogen II

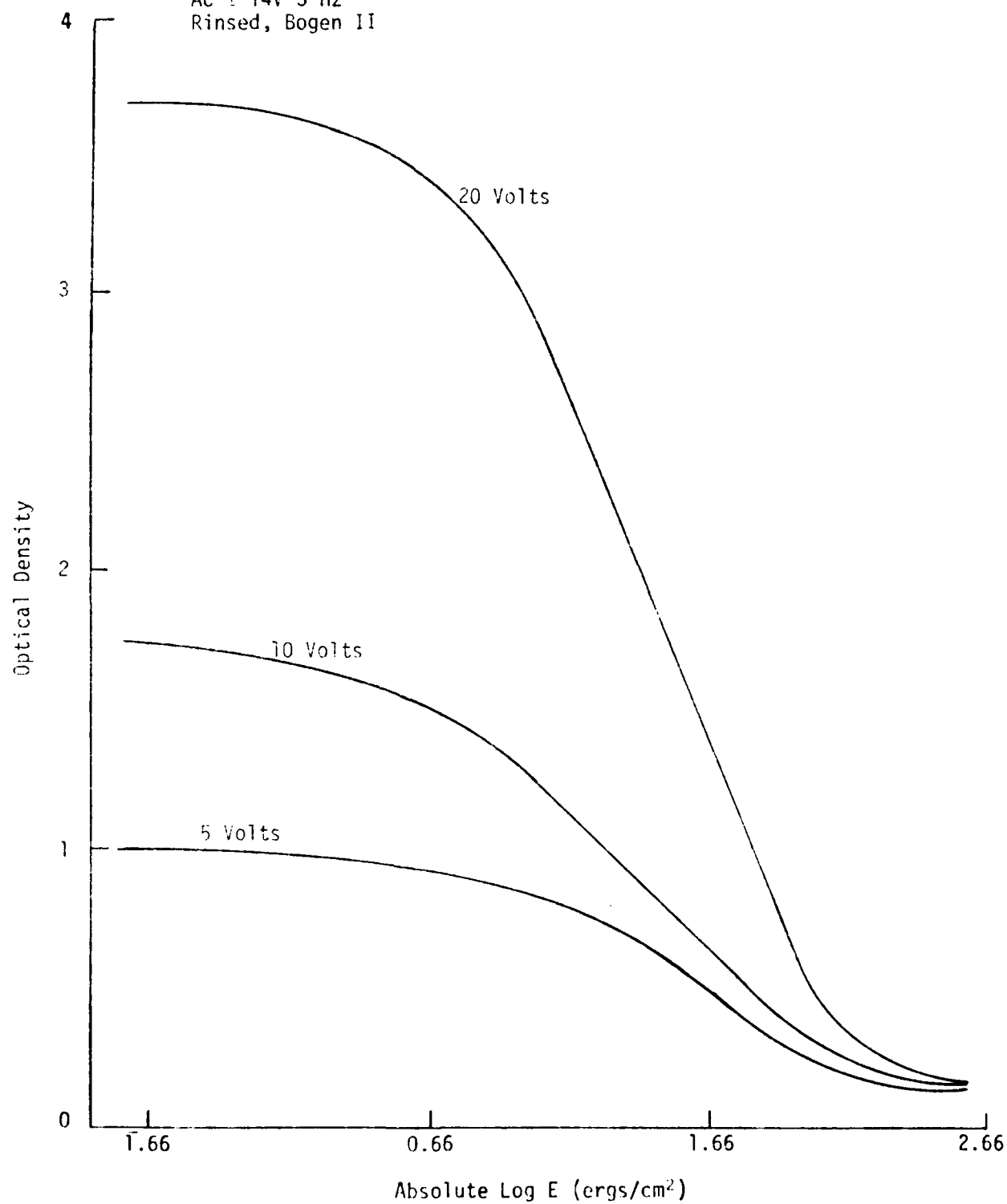


Figure 21. Step Wedge Response to Surface Voltage

CR-42 AP81200W 200 gm/kg

Tone 5 sec.  
AC  $\pm$  14 V 3 Hz  
Rinsed, Bogen II  
Film 194-1 #27

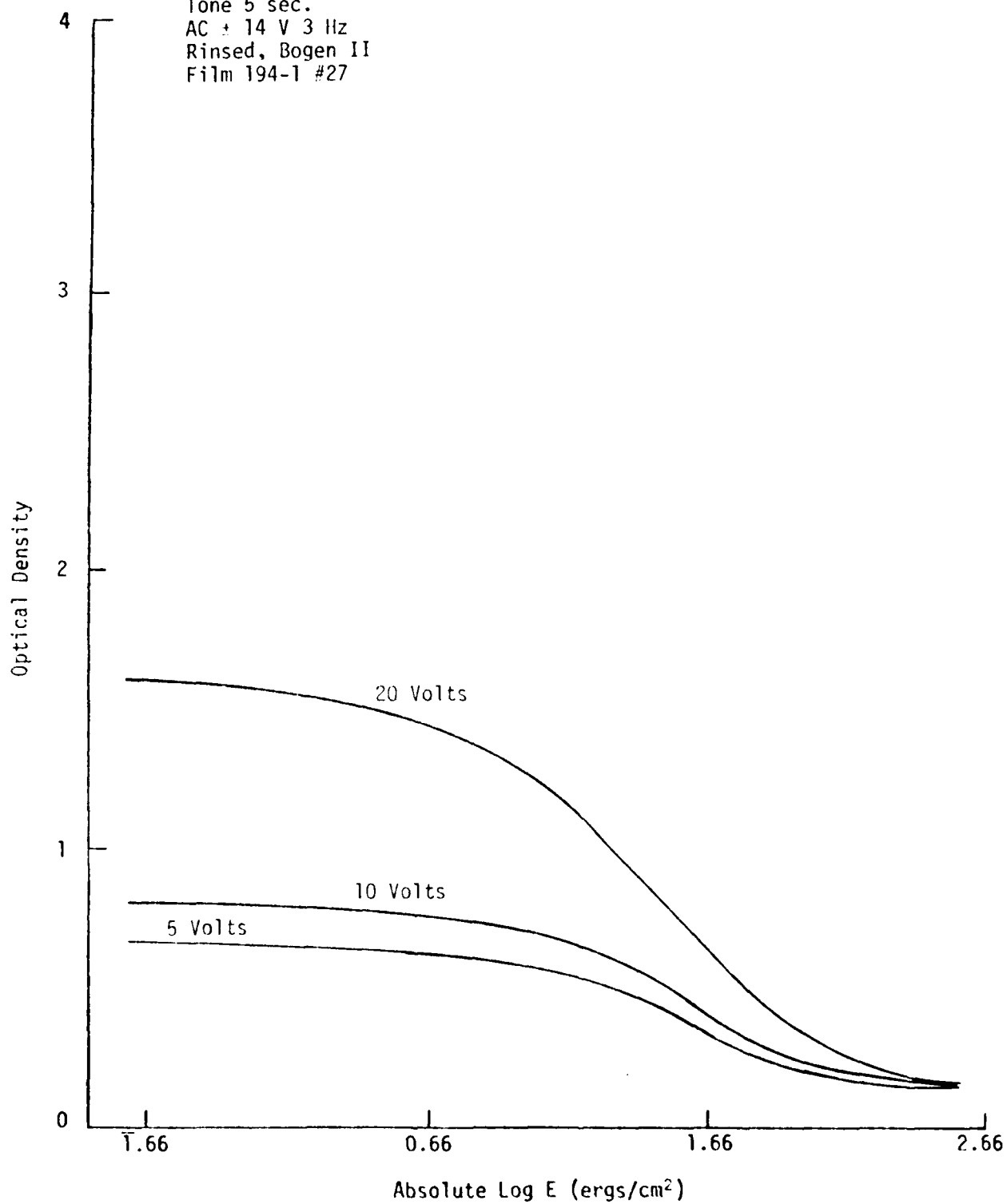


Figure 22. Step Wedge Response to Surface Voltage

CR-42 AP81200W 200 gm/kg

Tone 10 sec  
AC  $\pm 14$  V 3 Hz  
Rinsed, Bogen II  
Film 194-1 #27

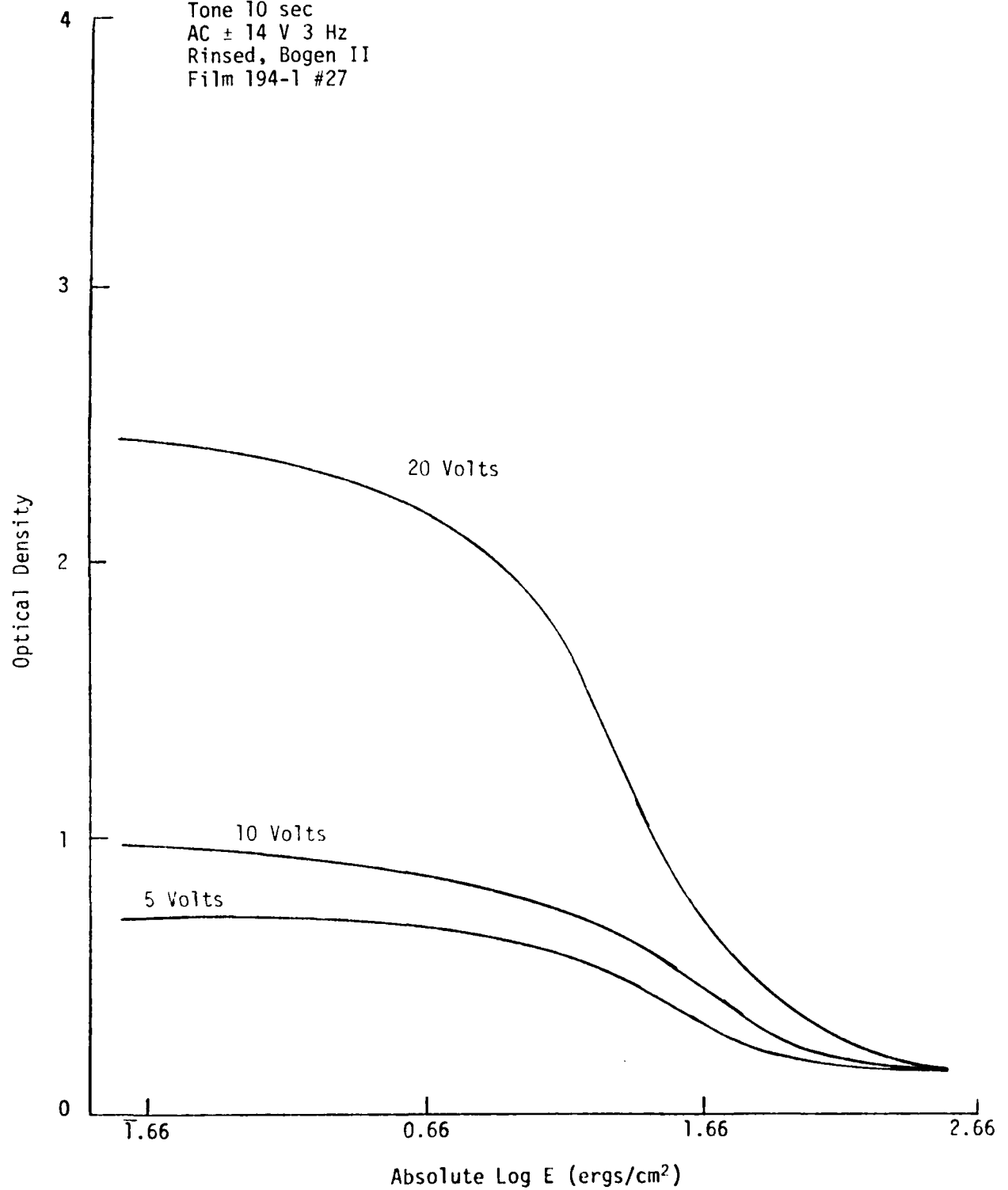


Figure 23. Step Wedge Response to Surface Voltage

CR-42 AP81200W 200 gm/kg

Tone 30 sec  
AC  $\pm$  14 V 3 Hz  
Rinsed, Bogen II  
Film 194-1 #27

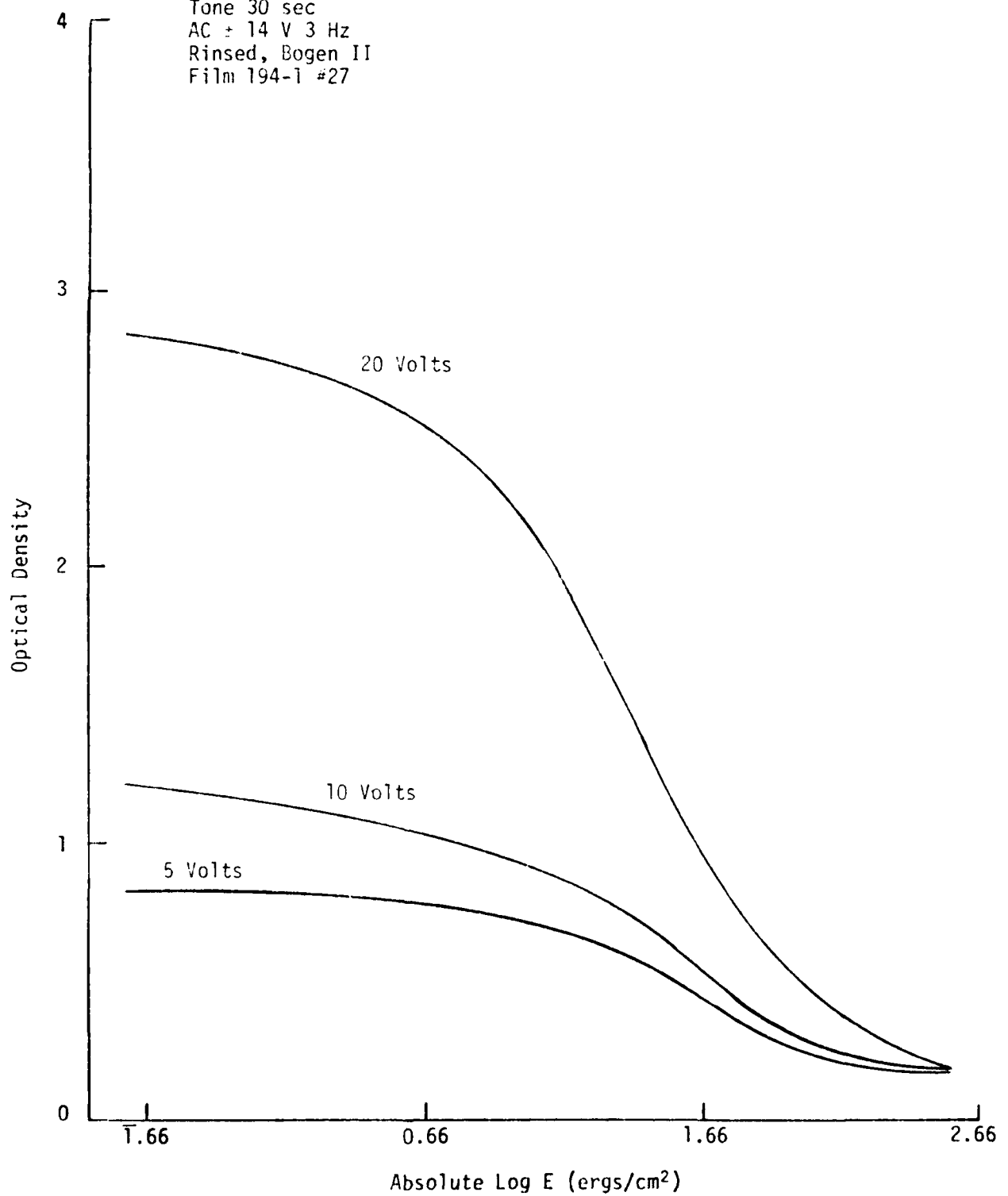


Figure 24. Step Wedge Response to Surface Voltage

TABLE 4

Gamma Range - CR-53

<u>Toner Conc. (g/Kg)</u>	<u>Toning Time (sec)</u>	<u>V</u>	<u>D<sub>max</sub></u>	<u>D<sub>min</sub></u>	<u>γ</u>
50	5	5	0.60	0.14	0.3
50	5	10	0.90	0.14	0.5
50	5	20	1.20	0.14	0.9
50	10	5	0.72	0.12	0.4
50	10	10	1.10	0.11	0.7
50	10	20	1.51	0.12	1.3
50	30	5	0.94	0.12	0.5
50	30	10	1.42	0.14	0.8
50	30	20	2.01	0.14	1.9
100	5	5	0.66	0.12	0.3
100	5	10	1.00	0.14	0.5
100	5	20	1.84	0.18	1.8
100	10	5	0.71	0.14	0.3
100	10	10	1.35	0.14	0.8
100	10	20	2.29	0.20	2.5
100	30	5	1.09	0.14	0.6
100	30	10	1.64	0.16	1.0
100	30	20	2.73	0.20	2.5
200	5	5	0.65	0.14	0.2
200	5	10	1.12	0.14	0.5
200	5	20	1.80	0.18	1.8
200	10	5	0.62	0.14	0.2
200	10	10	1.29	0.17	0.7
200	10	20	2.21	0.19	2.2
200	30	5	0.82	0.17	0.5
200	30	10	1.34	0.16	0.8
200	30	20	2.19	0.17	2.0

CR-53 9H080I 50 gm/kg

Tone 5 sec  
AC  $\pm$  14 V 3 Hz  
Rinsed, Bogen II

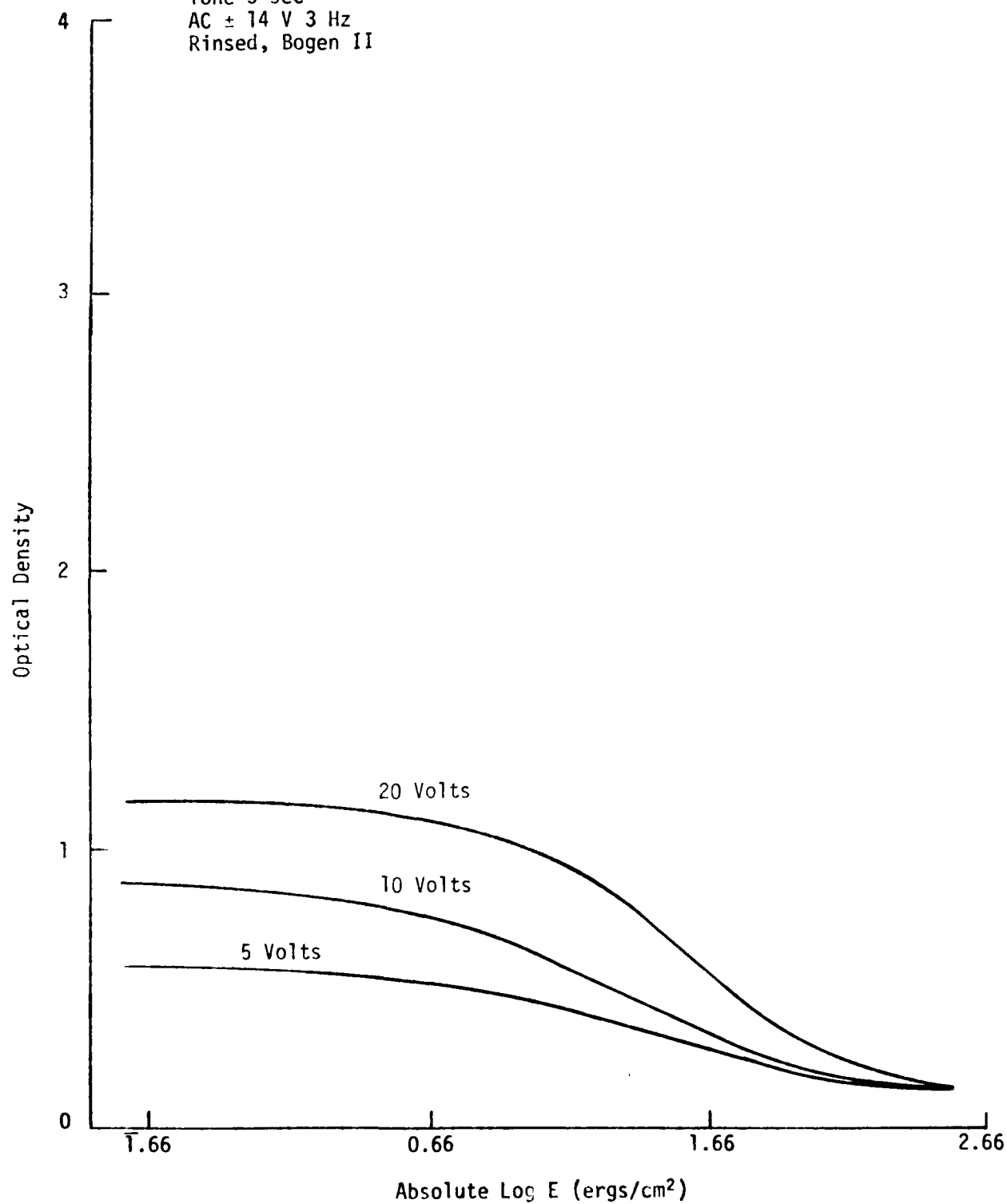


Figure 25. Step Wedge Response to Surface Voltage

CR-53 9H080I 50 gm/kg

Tone 10 sec.  
AC  $\pm 14$  V 3 Hz  
Rinsed, Bogen II

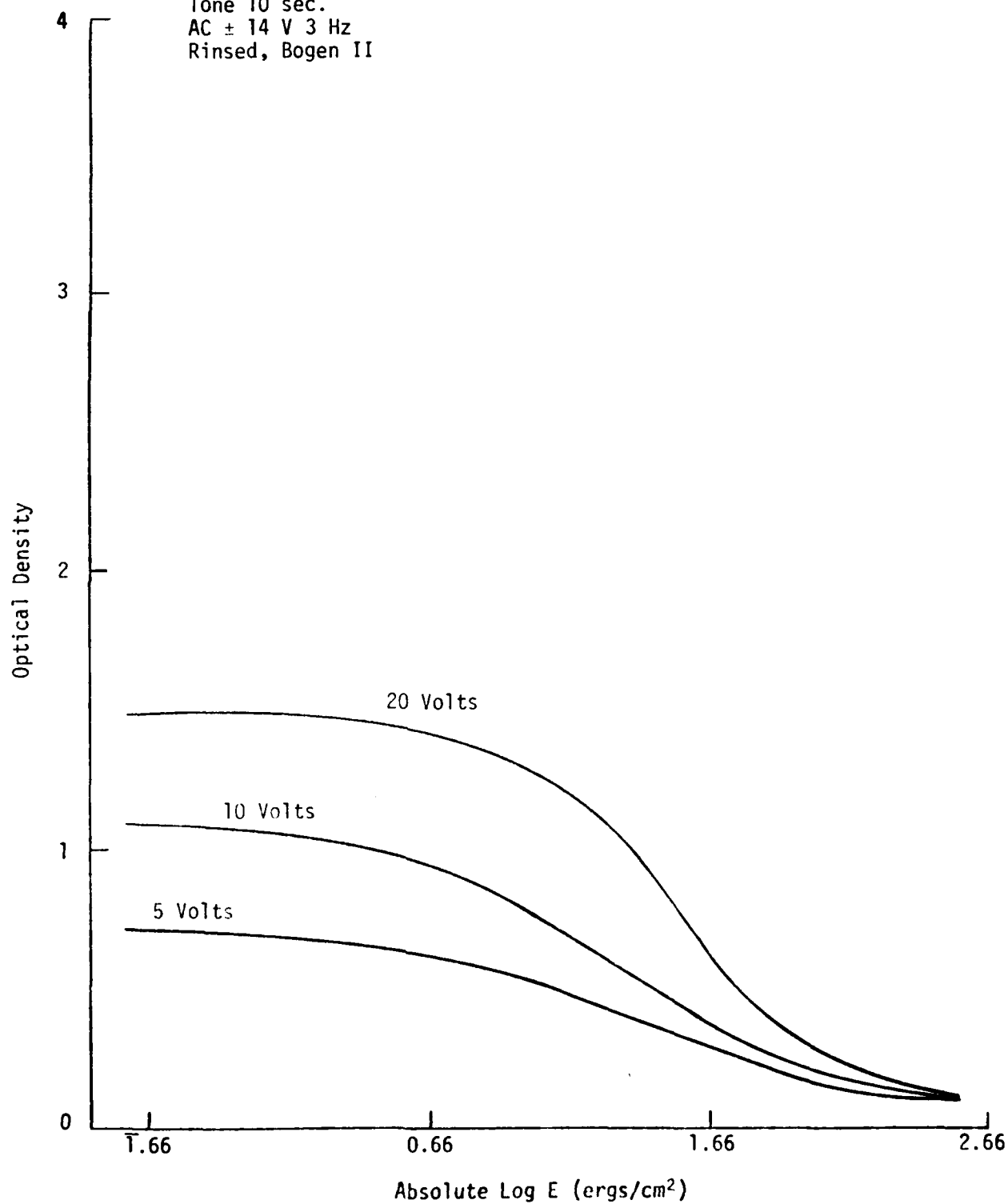


Figure 26. Step Wedge Response to Surface Voltage

CR-53 9H080I 50 gm/kg

Tone 30 sec  
AC  $\pm 14$  V 3 Hz  
Rinsed, Bogen II

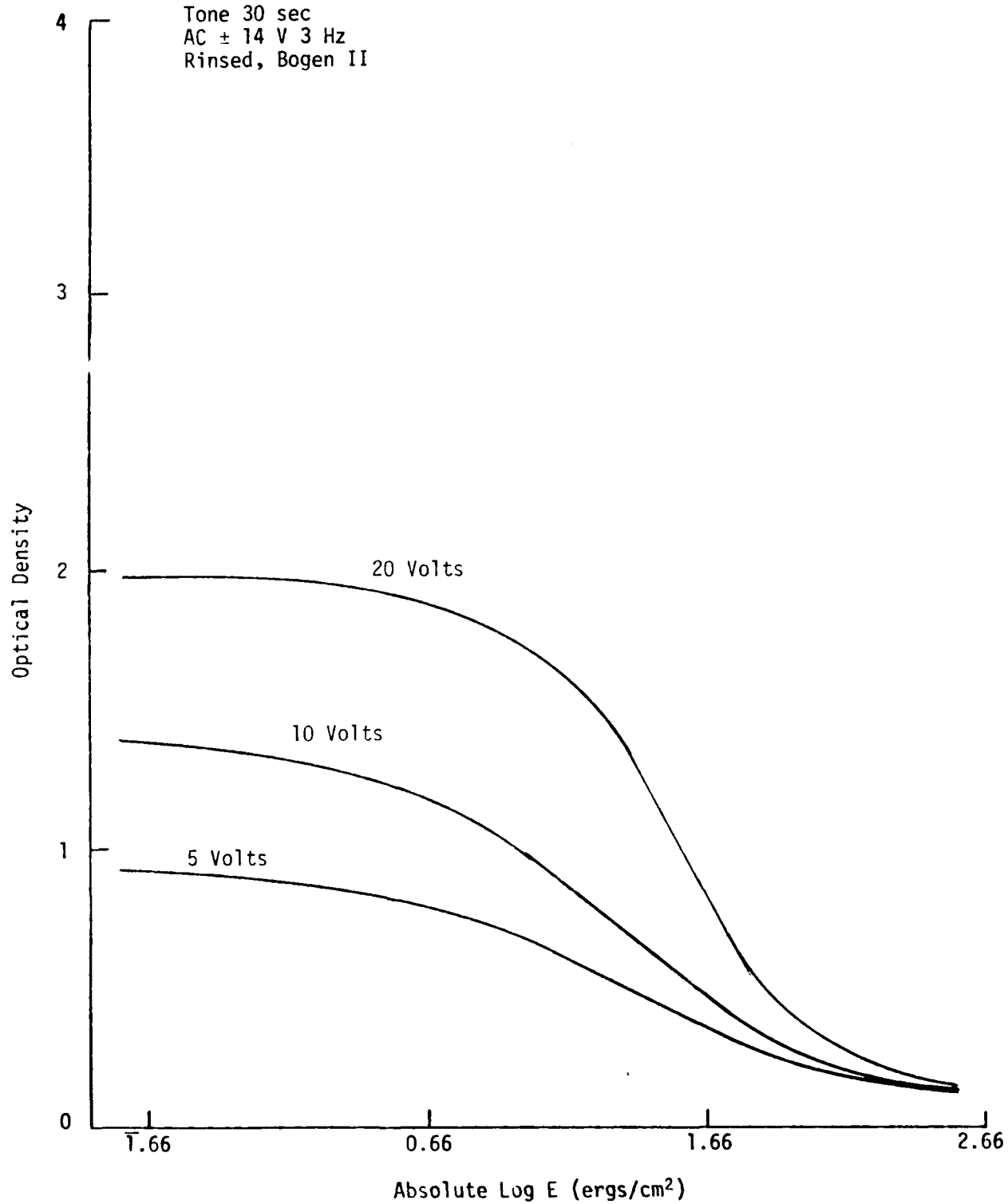


Figure 27. Step Wedge Response to Surface Voltage

CR-53 9H080I 100 gm/kg

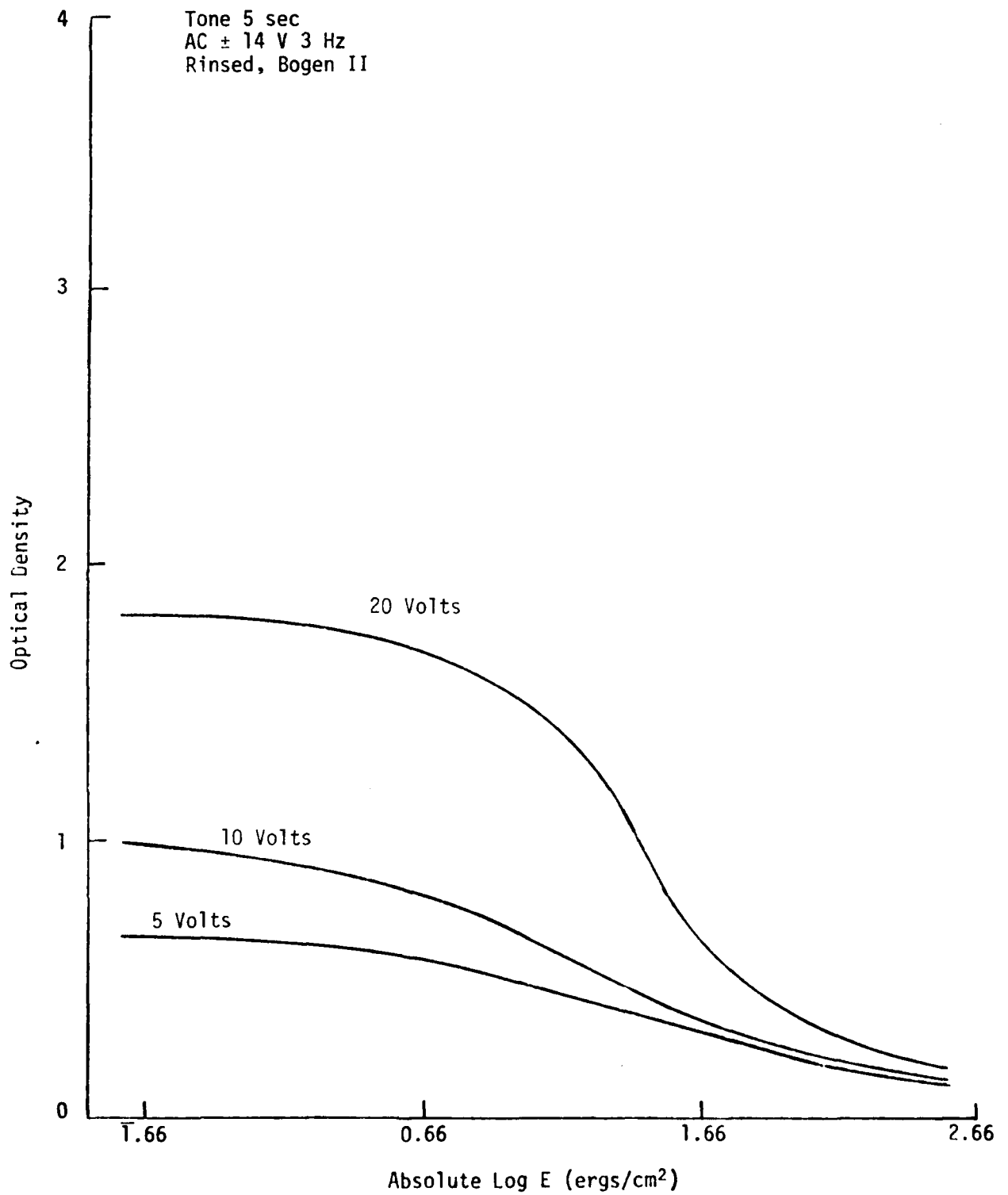


Figure 28. Step Wedge Response to Surface Voltage

CR-53 9H080I 100 gm/kg

Tone 10 sec  
AC  $\pm$  14 V 3 Hz  
Rinsed, Bogen II

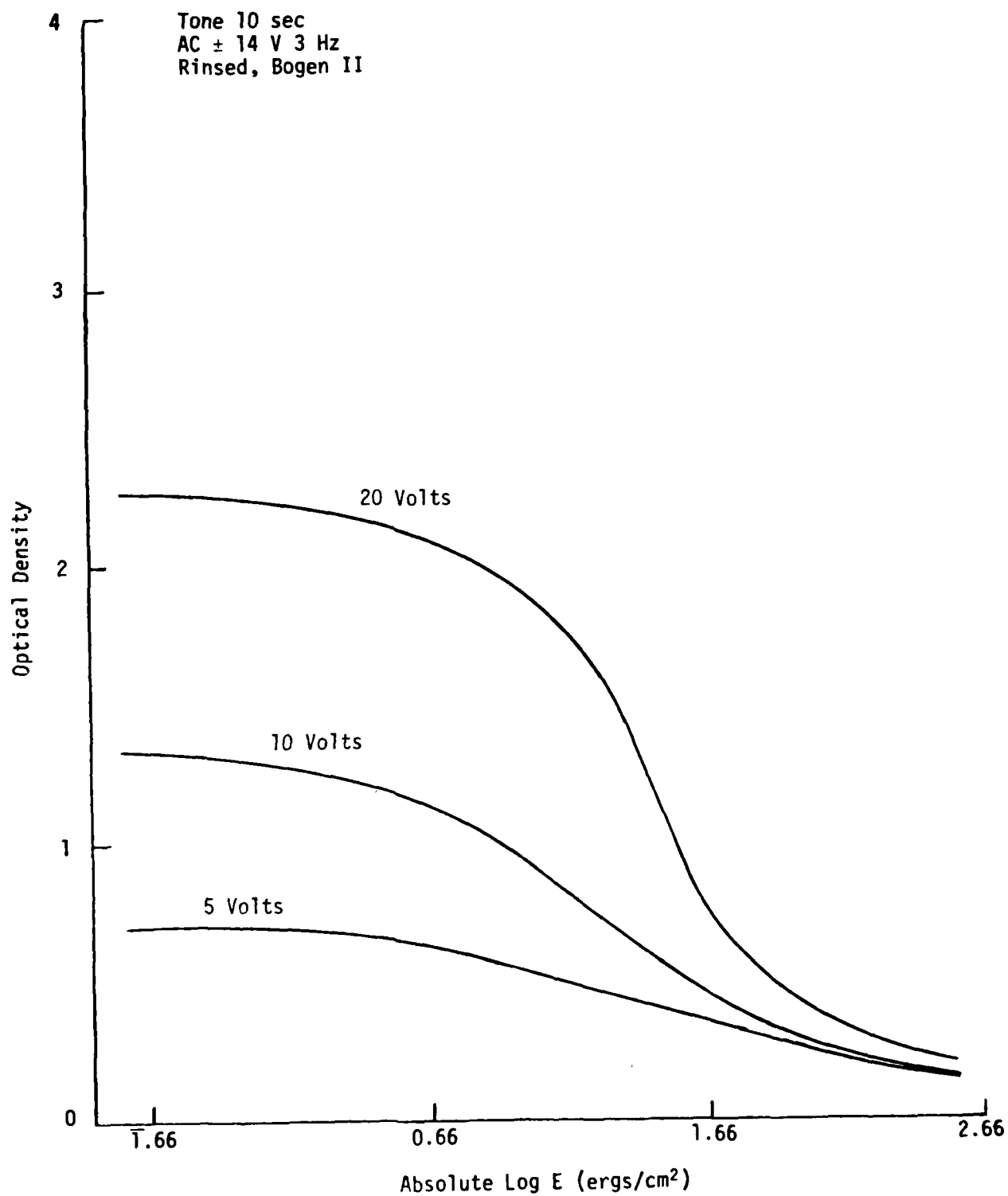


Figure 29. Step Wedge Response to Surface Voltage

CR-53 9H080I 100 gm/kg

Tone 30 sec  
AC  $\pm 14$  V 3 Hz  
Rinsed, Bogen II

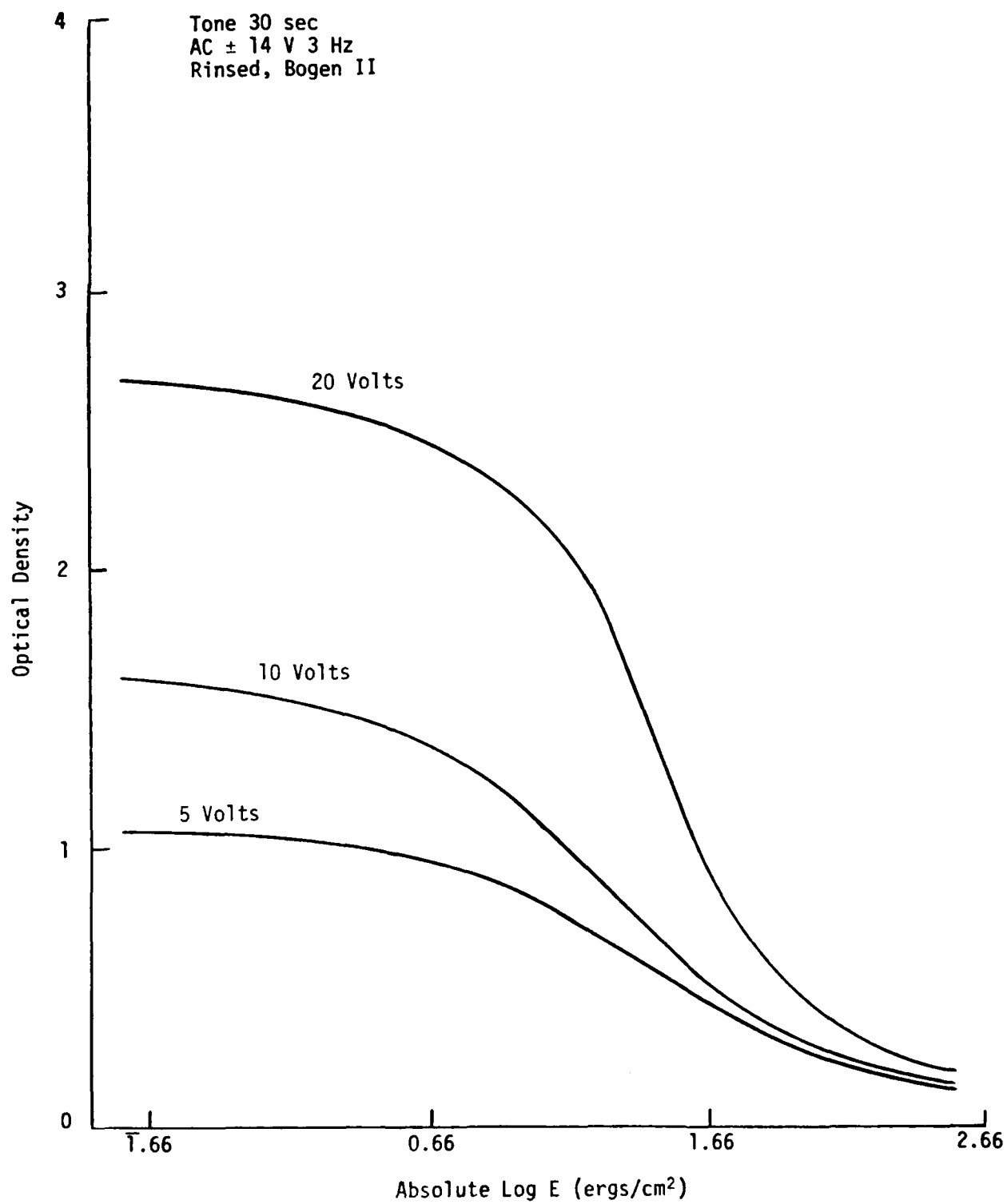


Figure 30. Step Wedge Response to Surface Voltage

CR-53 9H080I 200 gm/kg

Tone 5 sec  
AC  $\pm 14$  V 3 Hz  
Rinsed, Bogen II

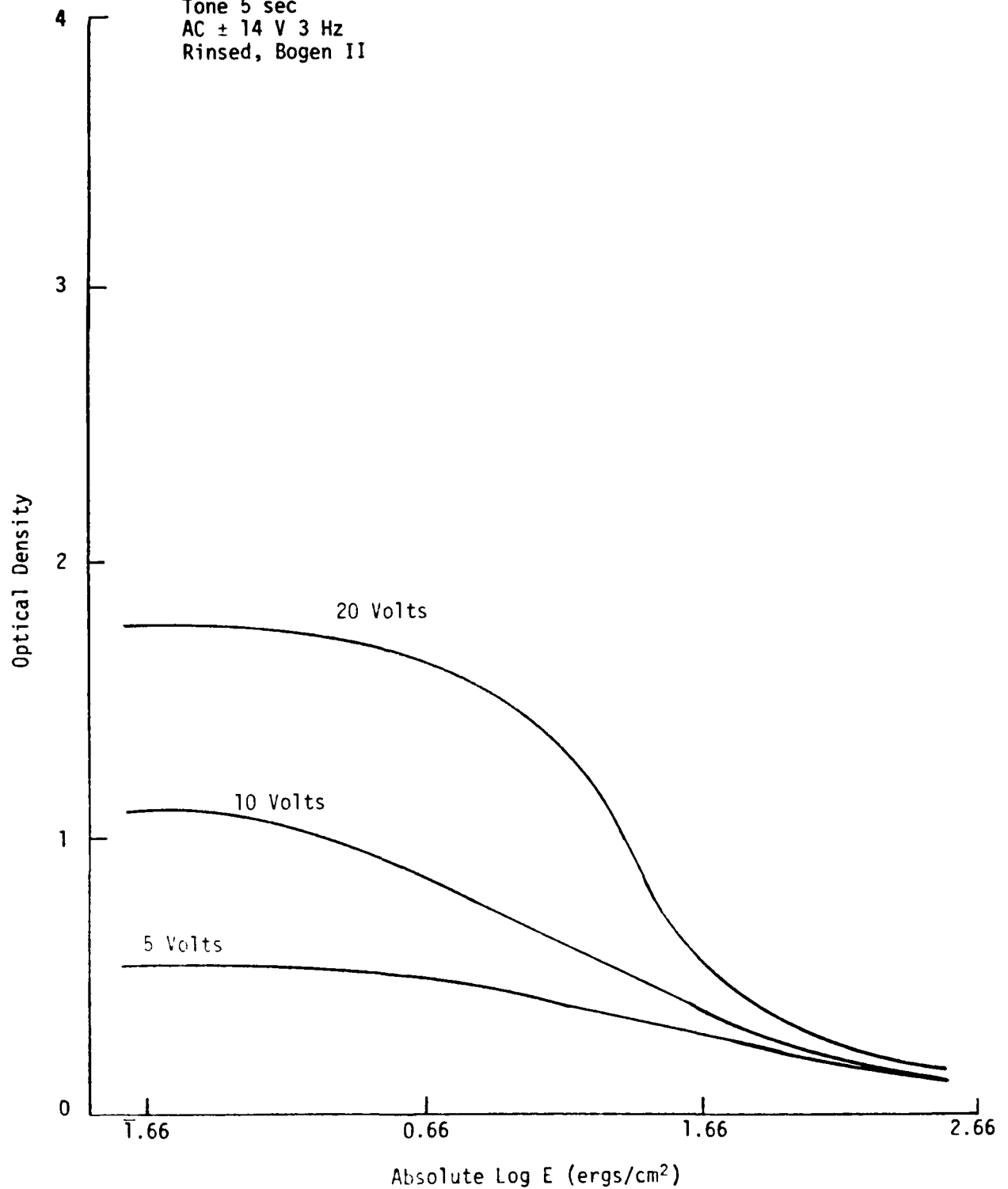


Figure 31. Step wedge Response to Surface Voltage

CR-53 9H080I 200 gm/kg

Tone 10 sec  
AC  $\pm$  14 V 3 Hz  
Rinsed, Bogen II

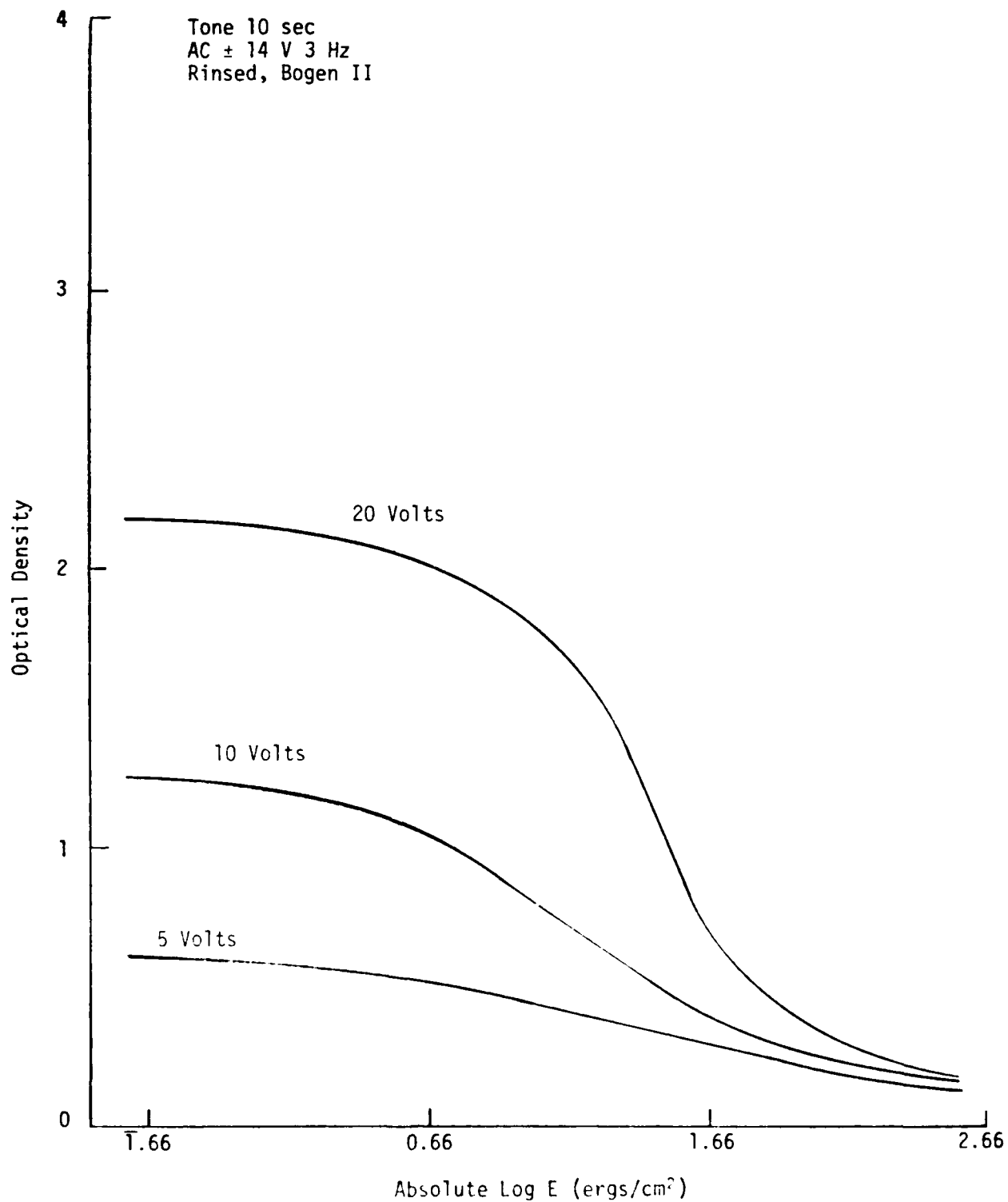


Figure 32. Step Wedge Response to Surface Voltage

CR-53 9H080I 200 gm/kg

Tone 30 sec

AC  $\pm$  14 V 3 Hz

Rinsed, Bogen II

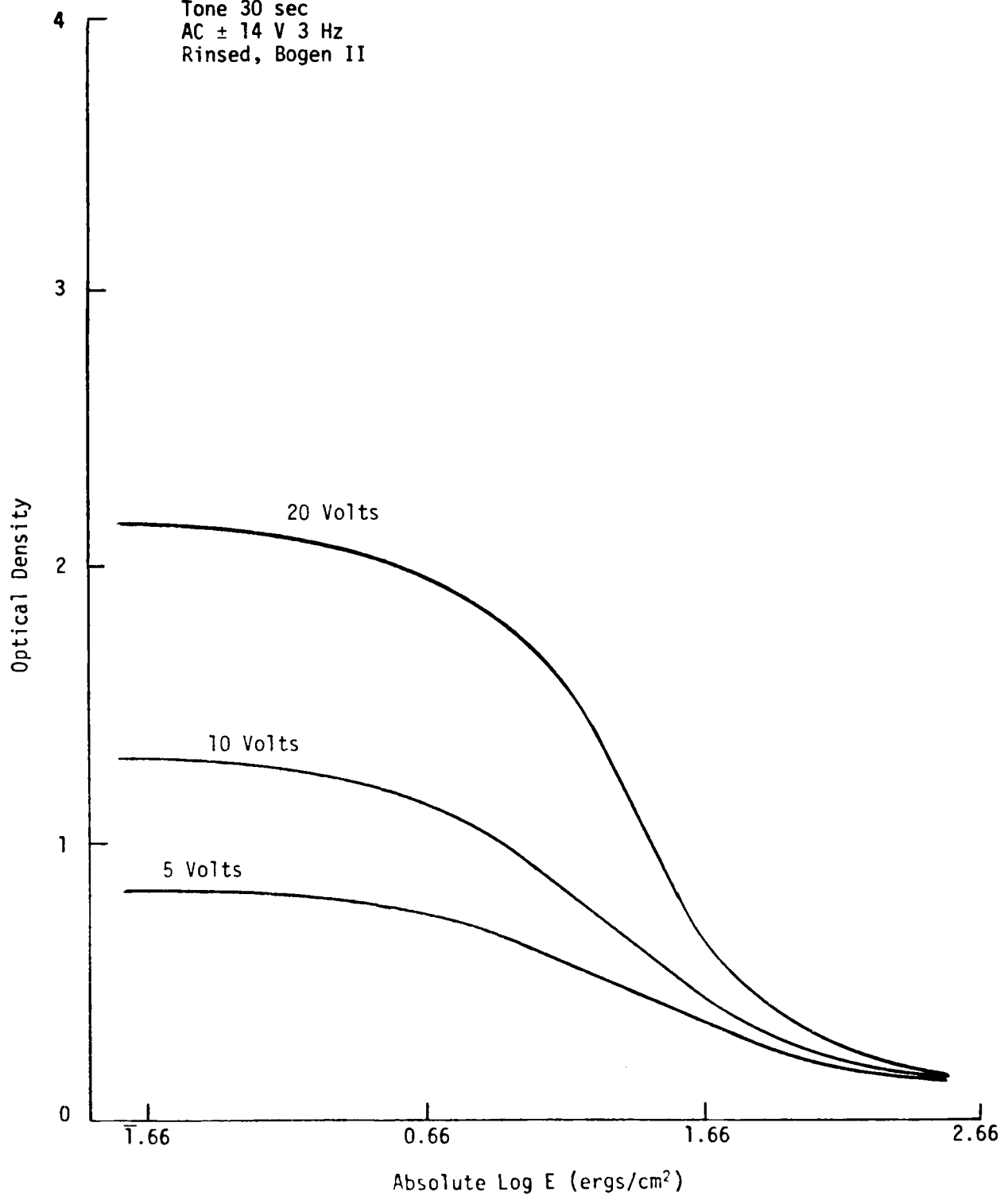


Figure 33. Step wedge Response to Surface Voltage

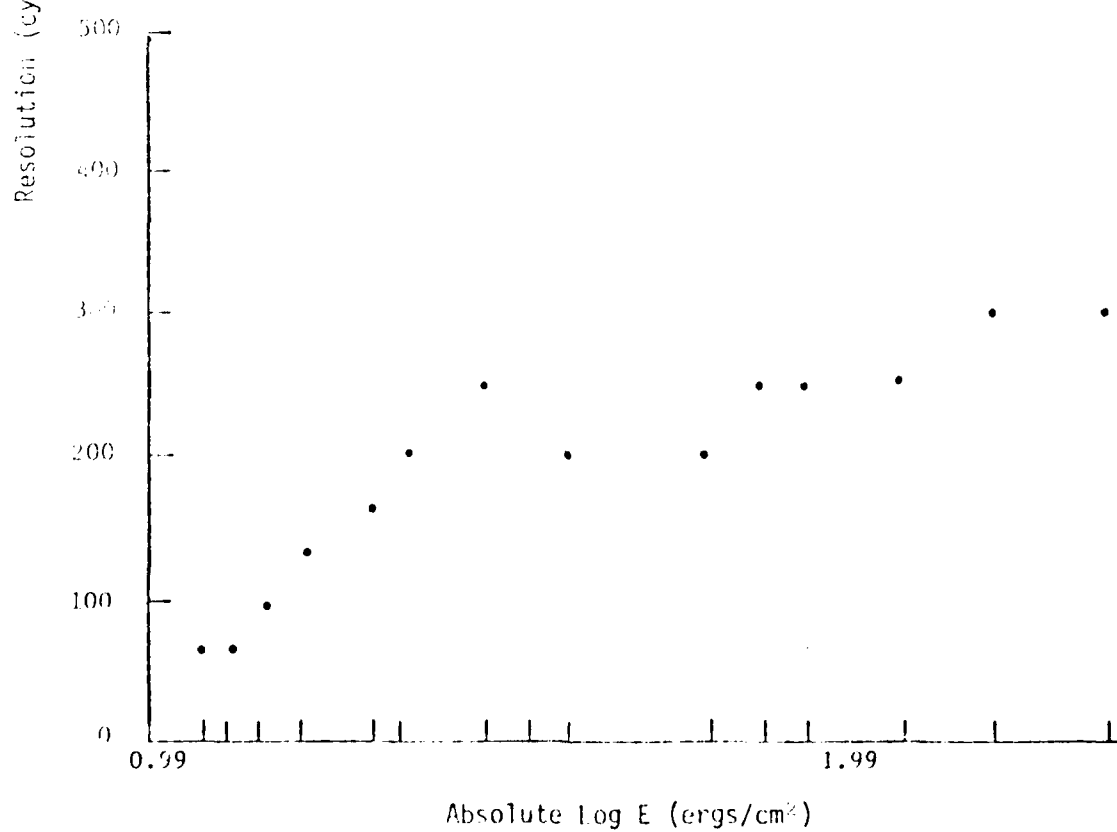
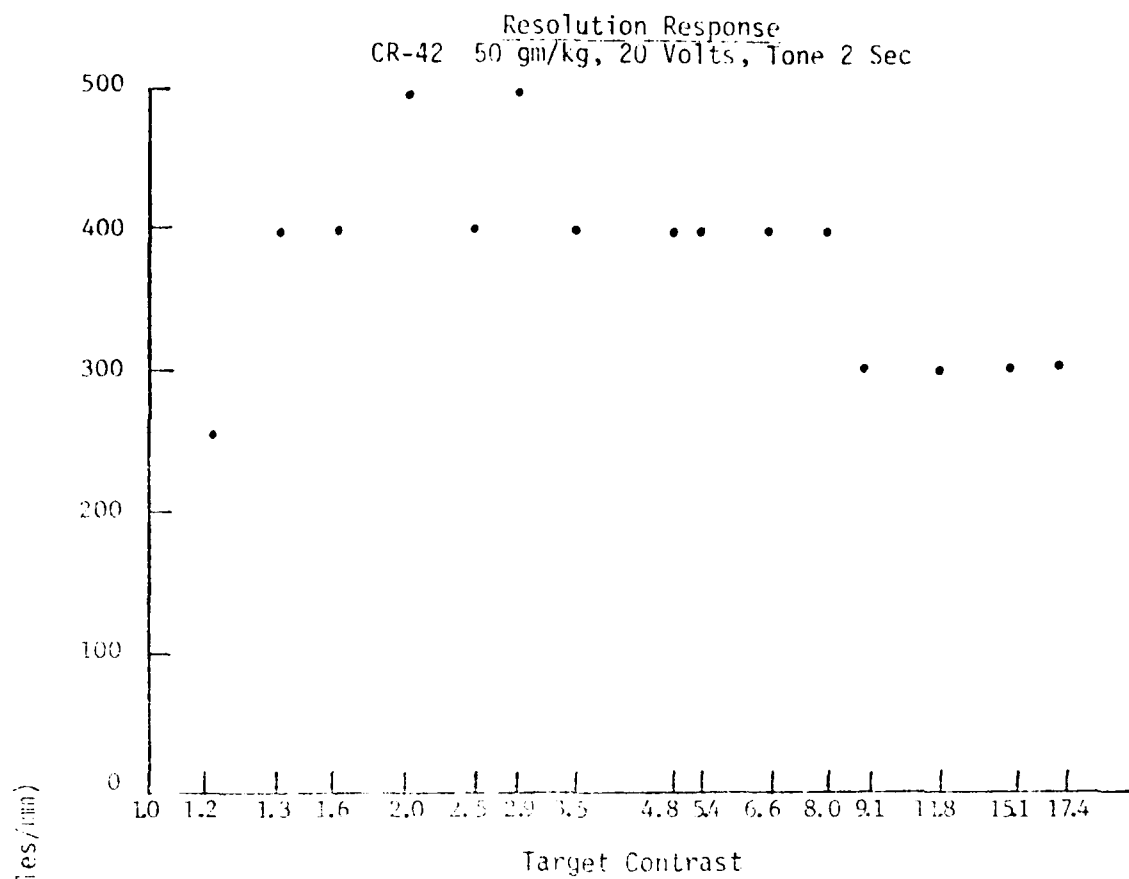


Figure 34

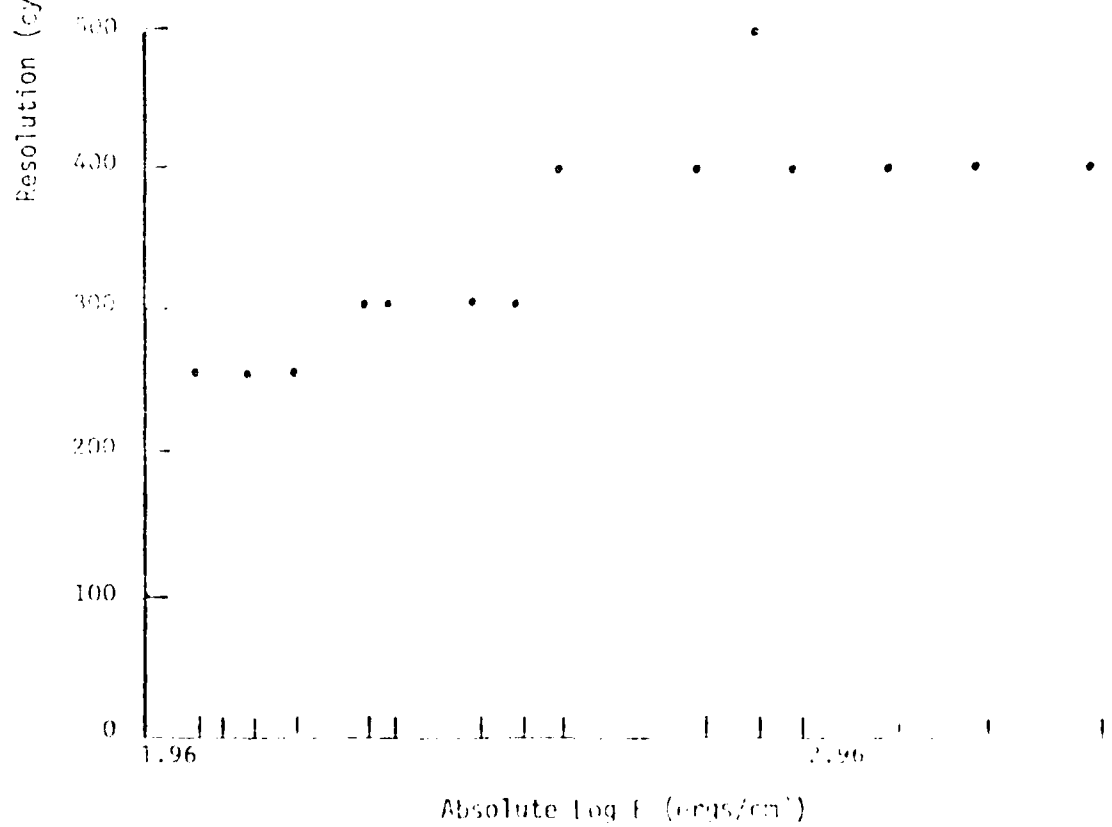
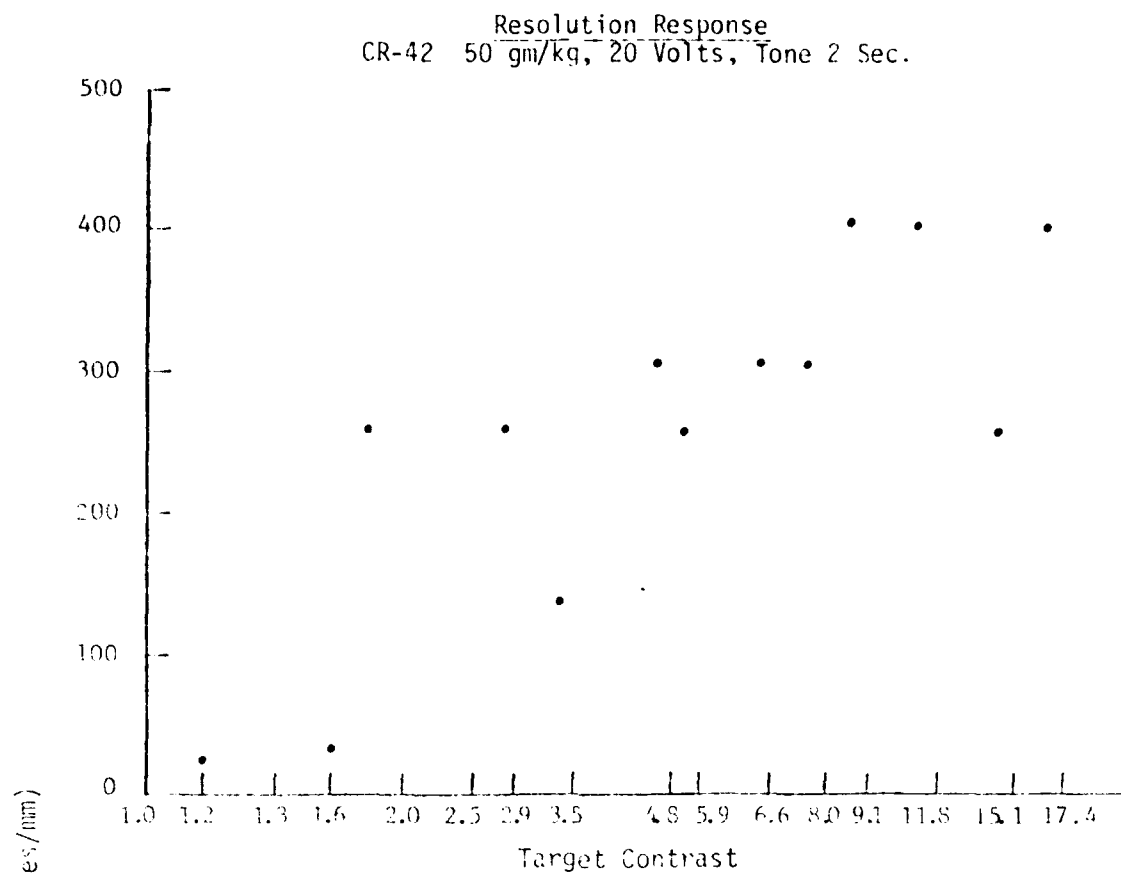


Figure 35

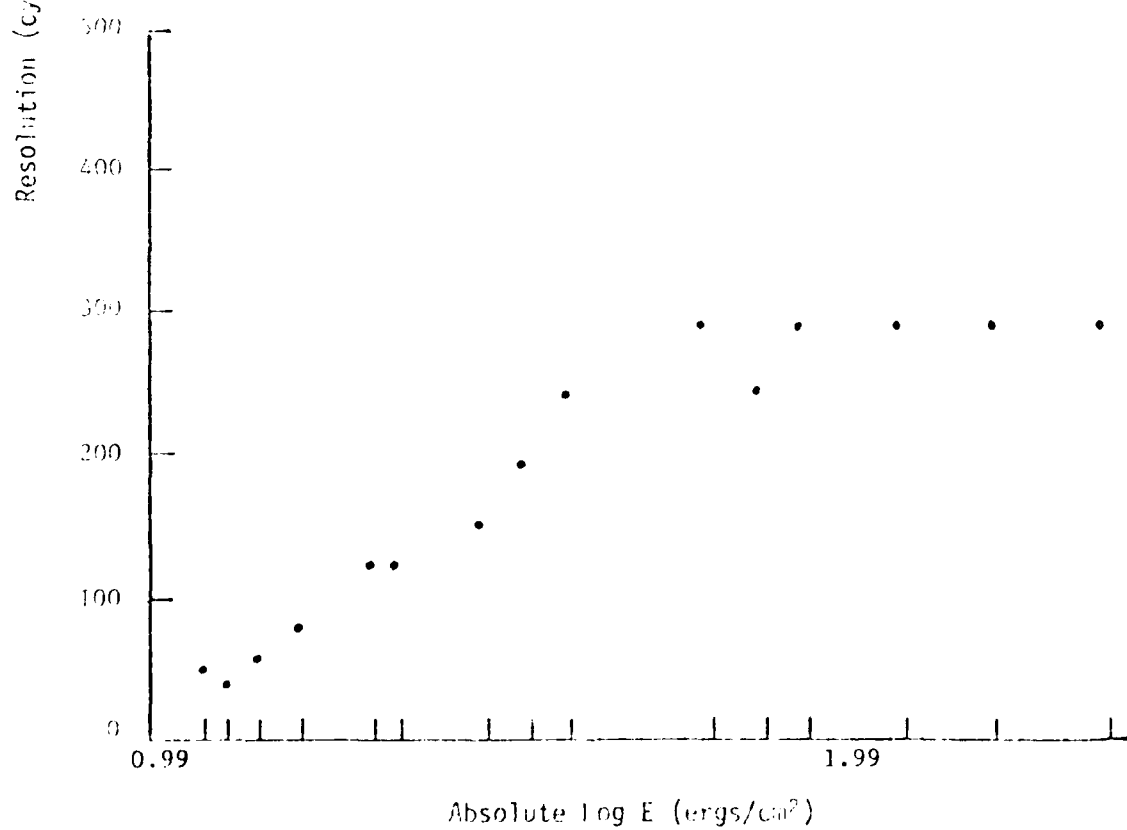
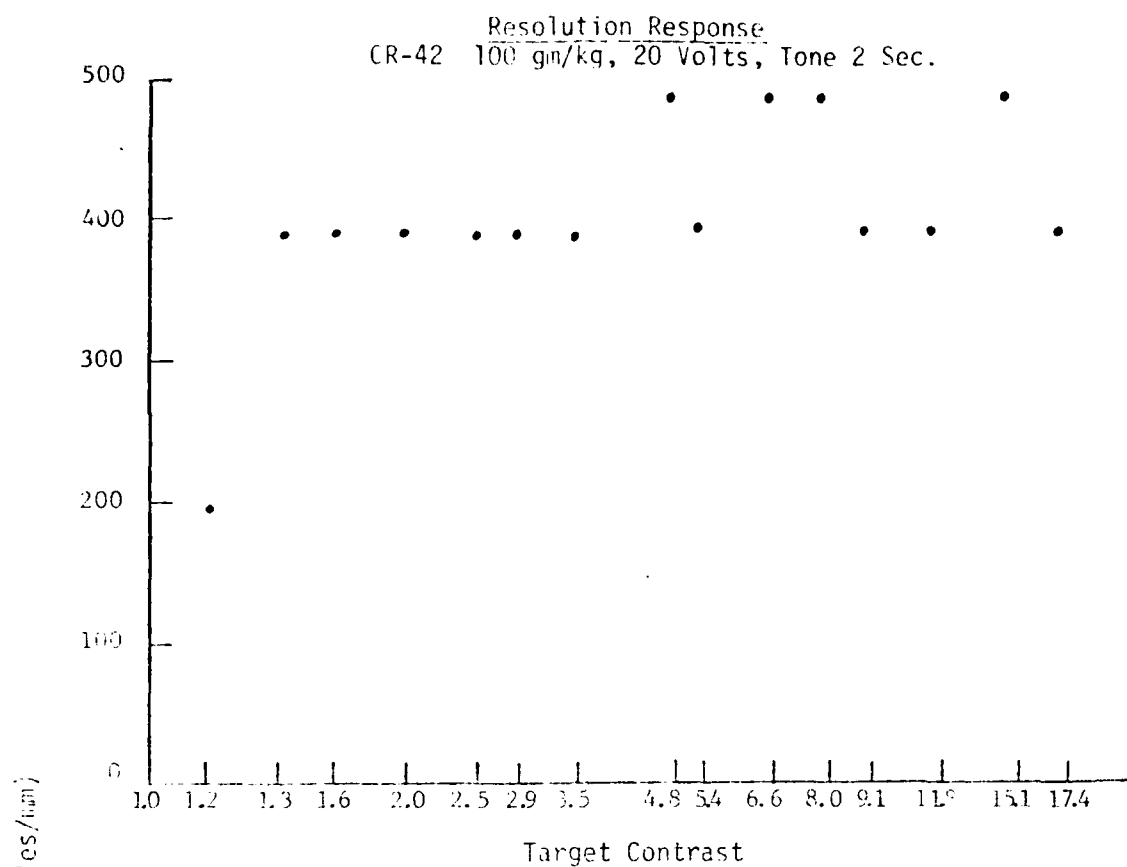


Figure 36

Resolution Response  
CR-42 100 gm/kg, 20 Volts, Tone 2 Sec.

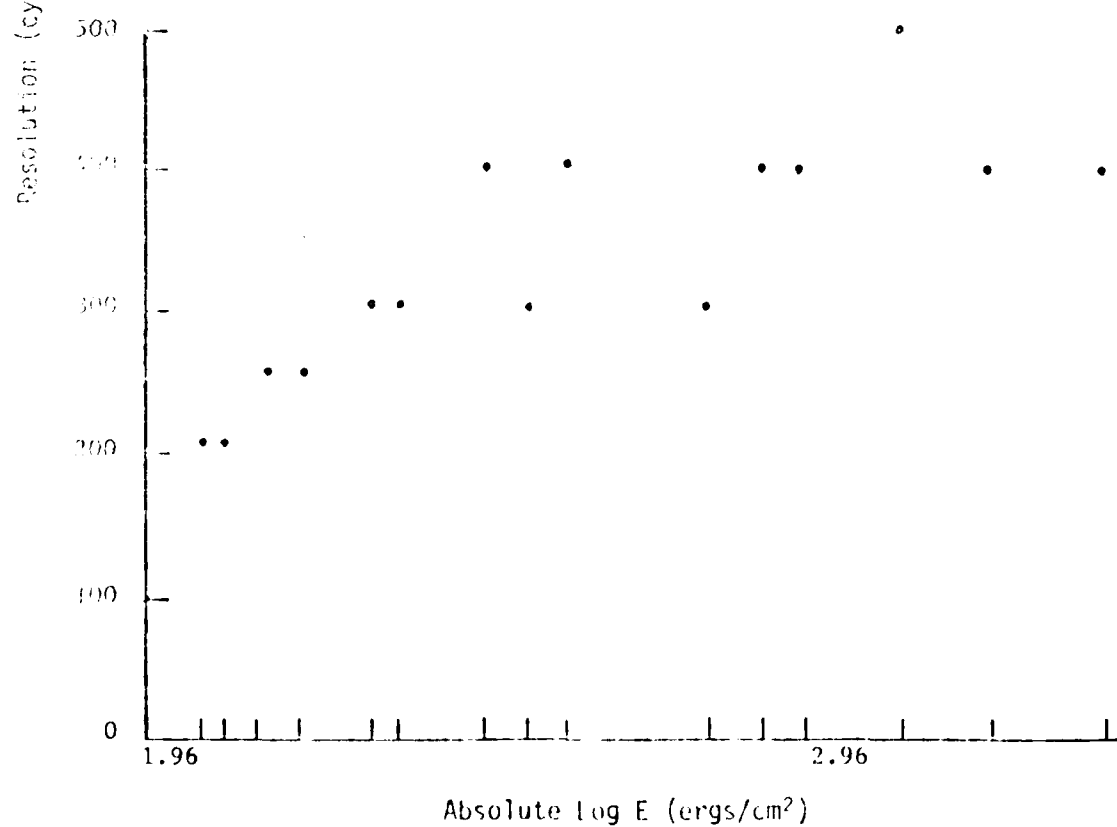
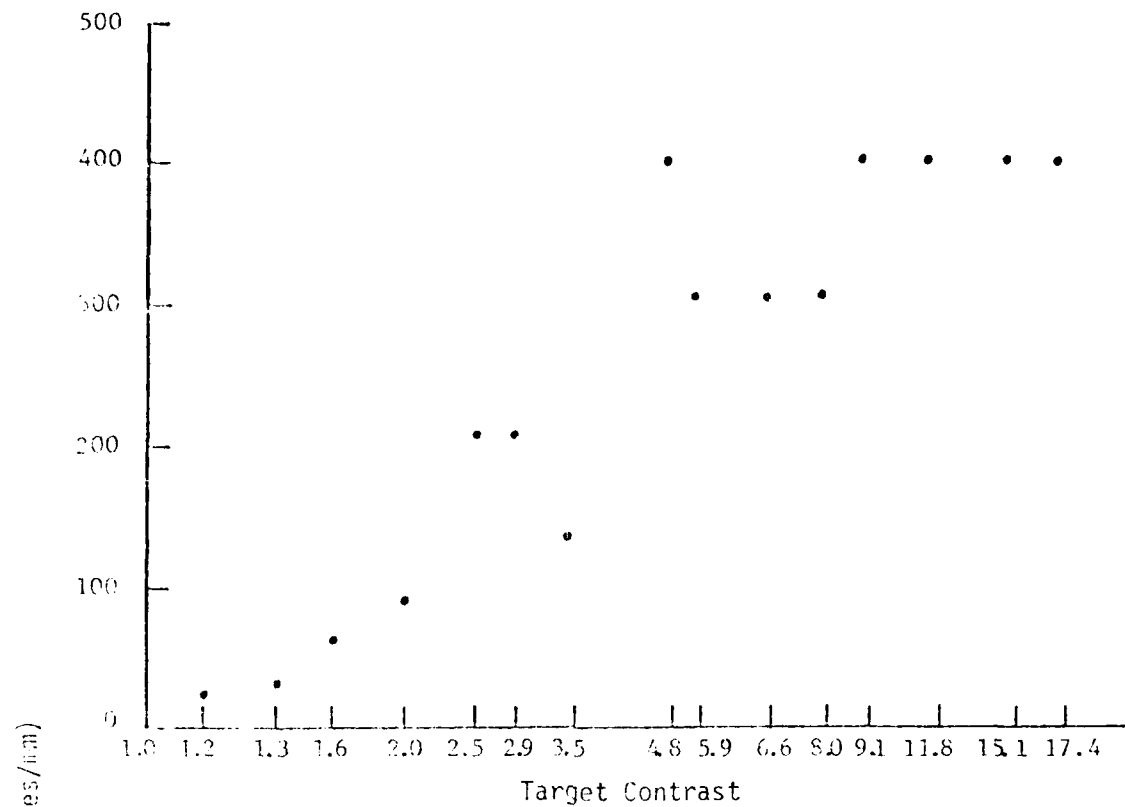


Figure 37

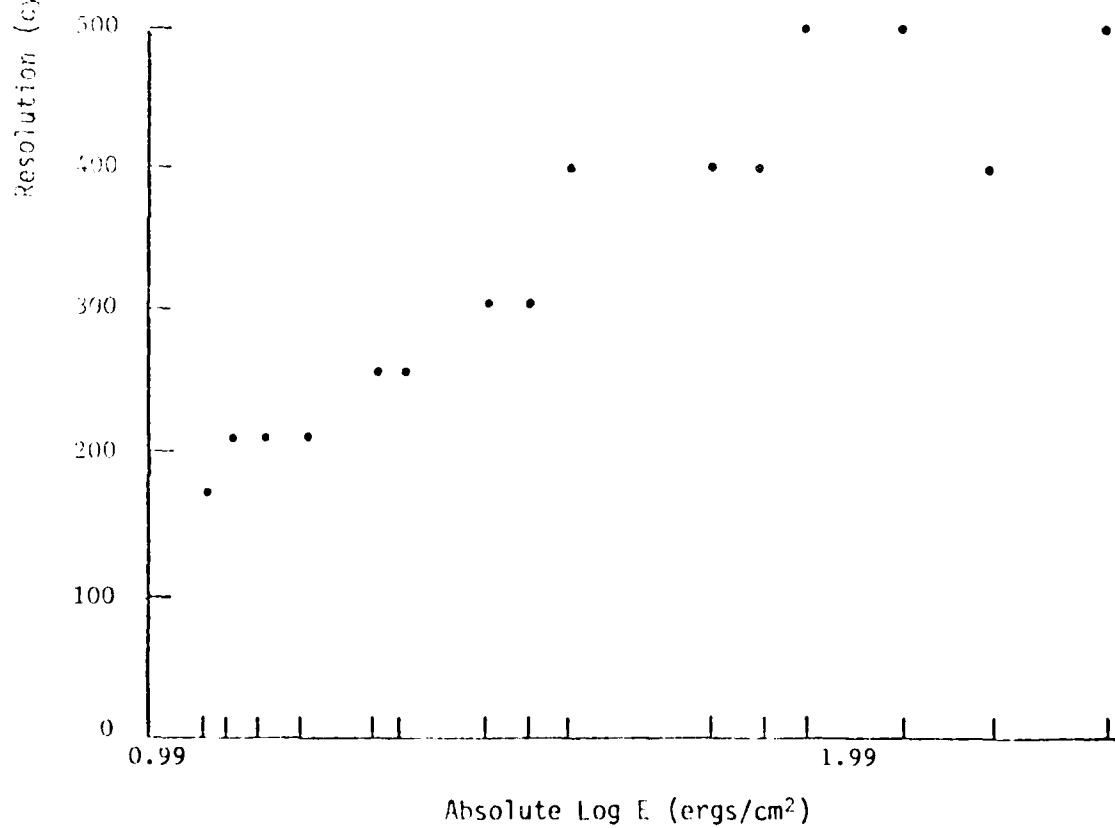
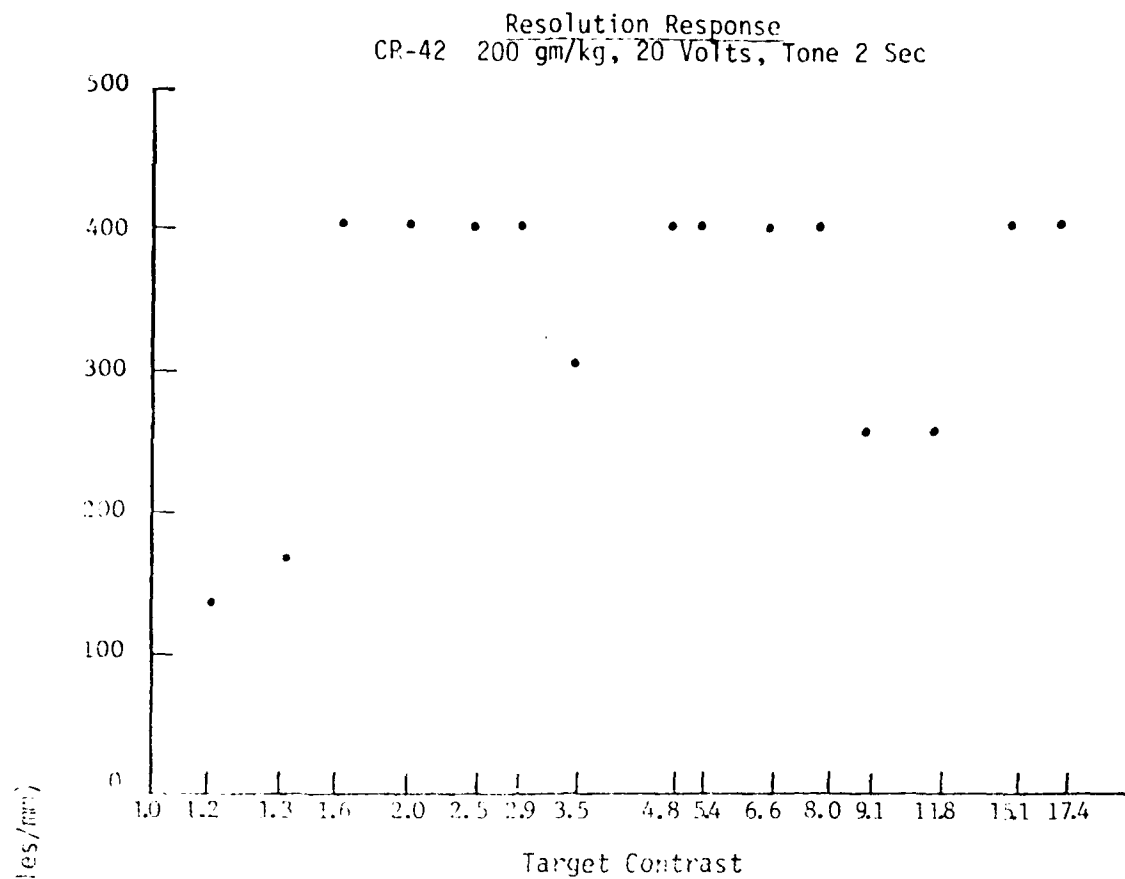


Figure 38

Resolution Response  
CR-42 200 gm/kg, 20 Volts, Tone 2 Sec.

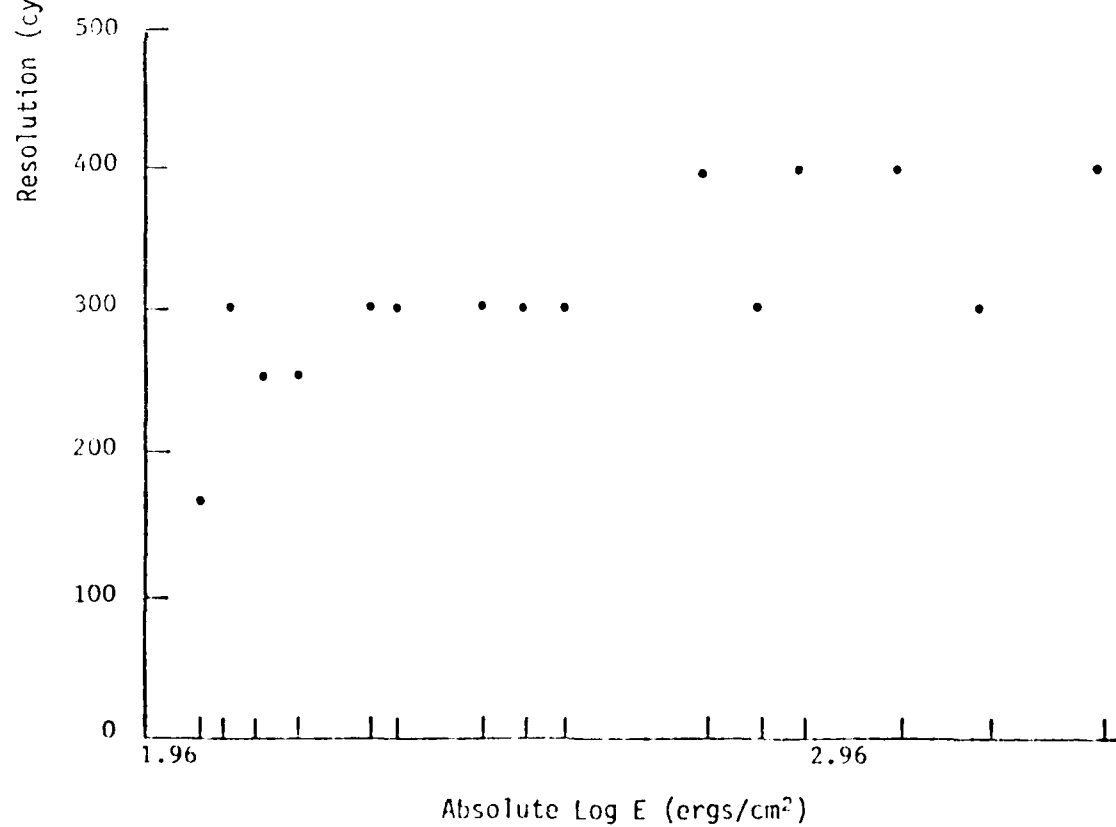
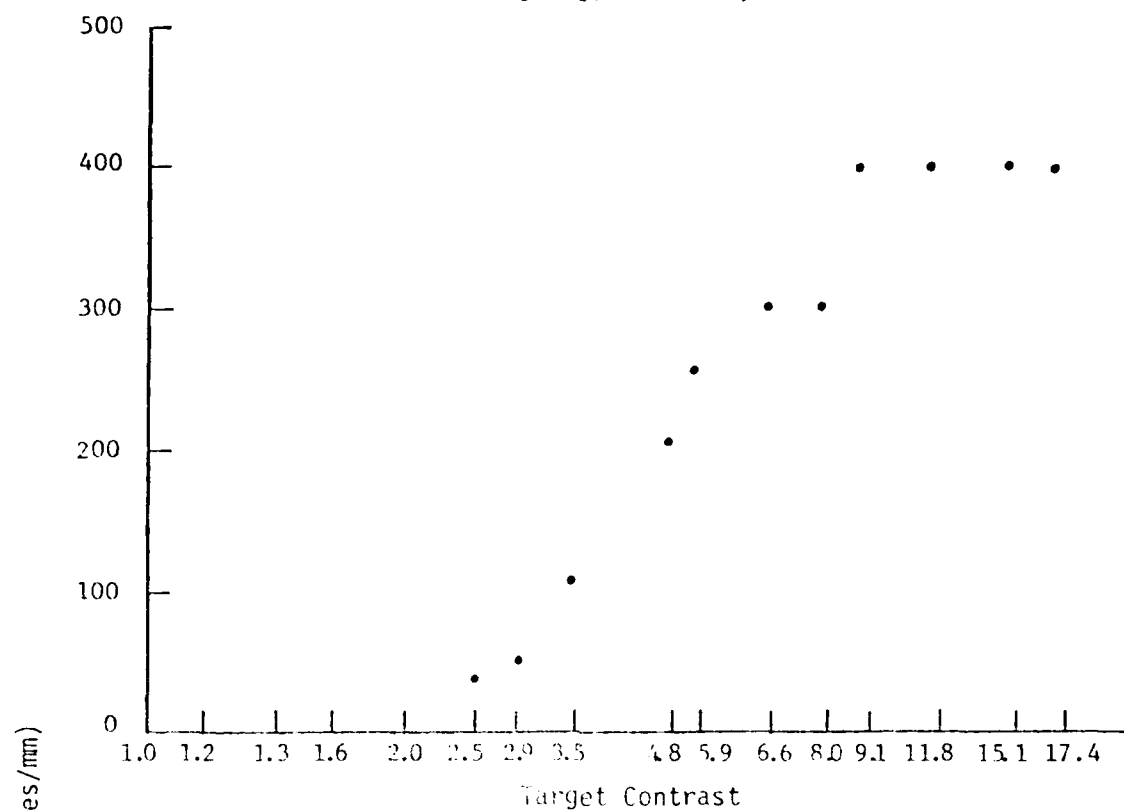


Figure 39

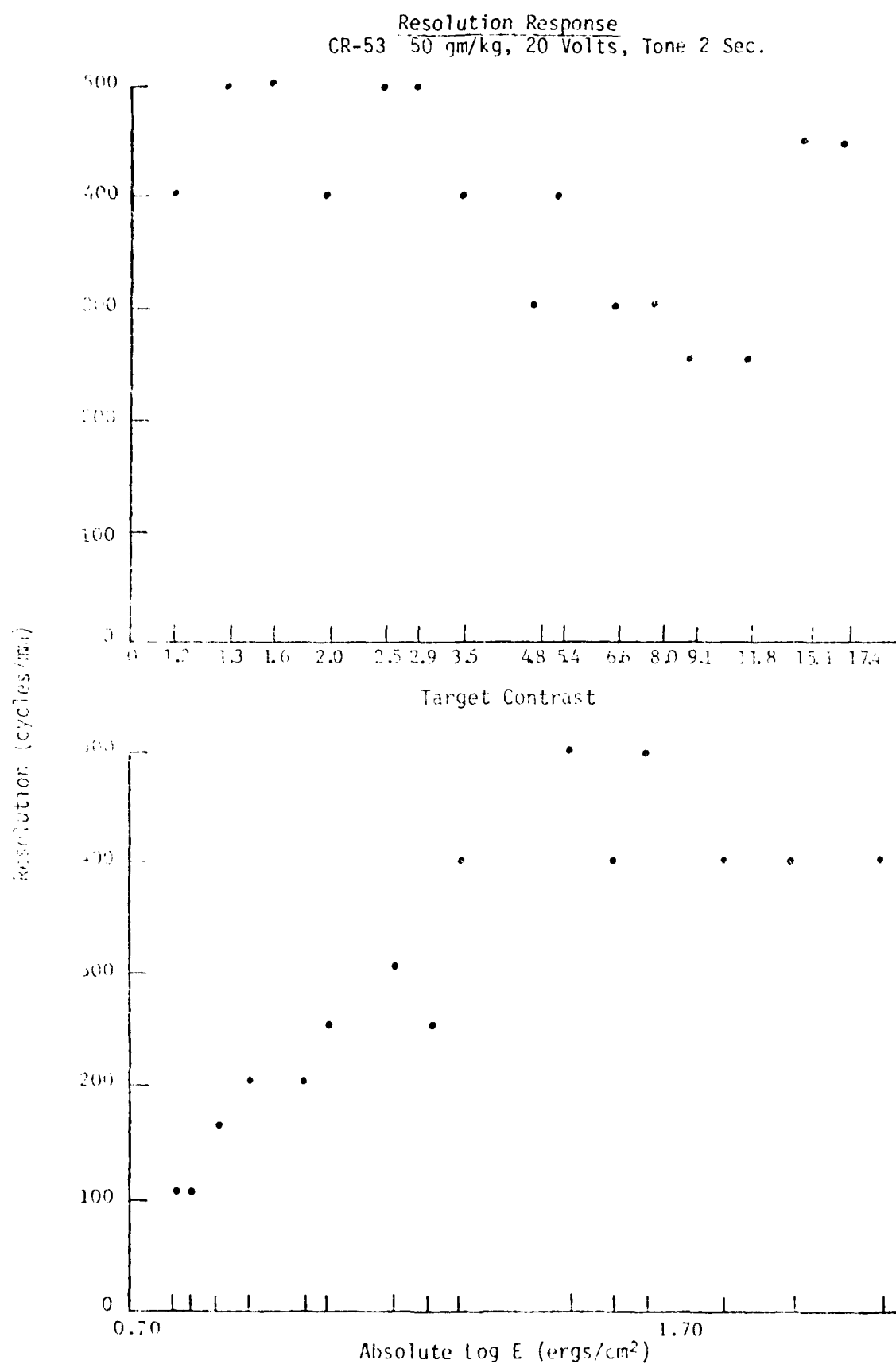
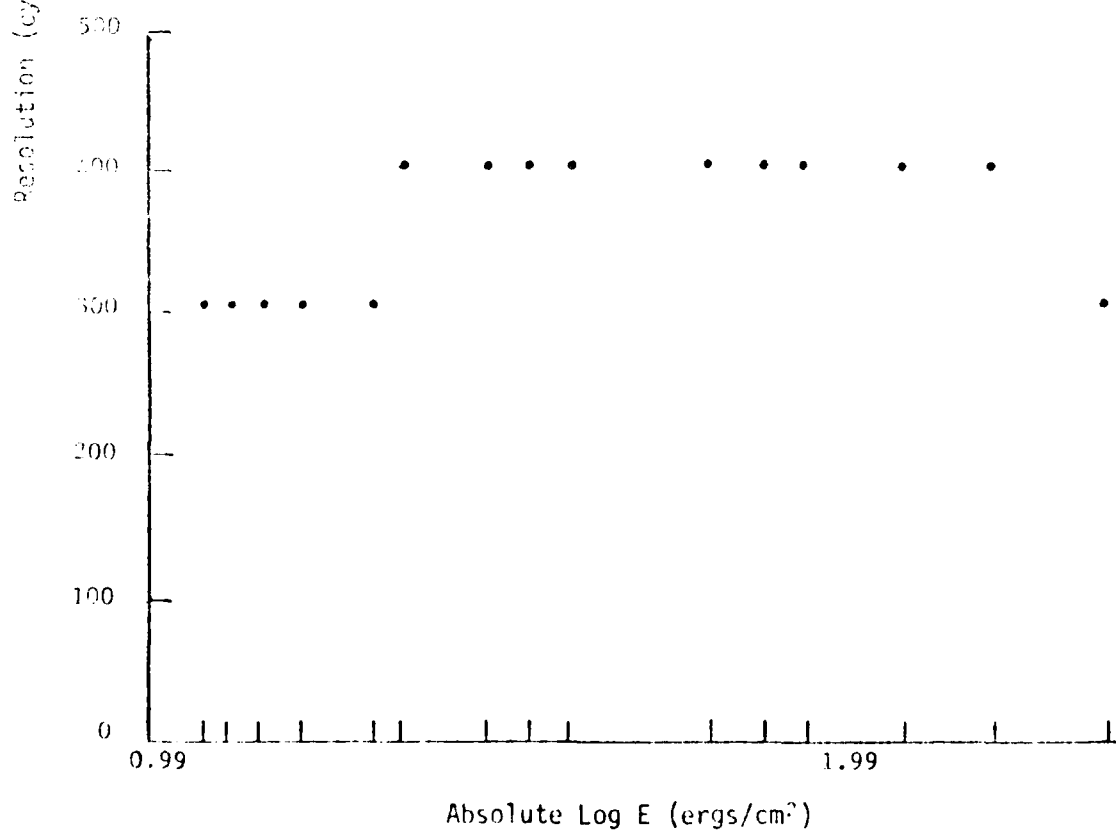
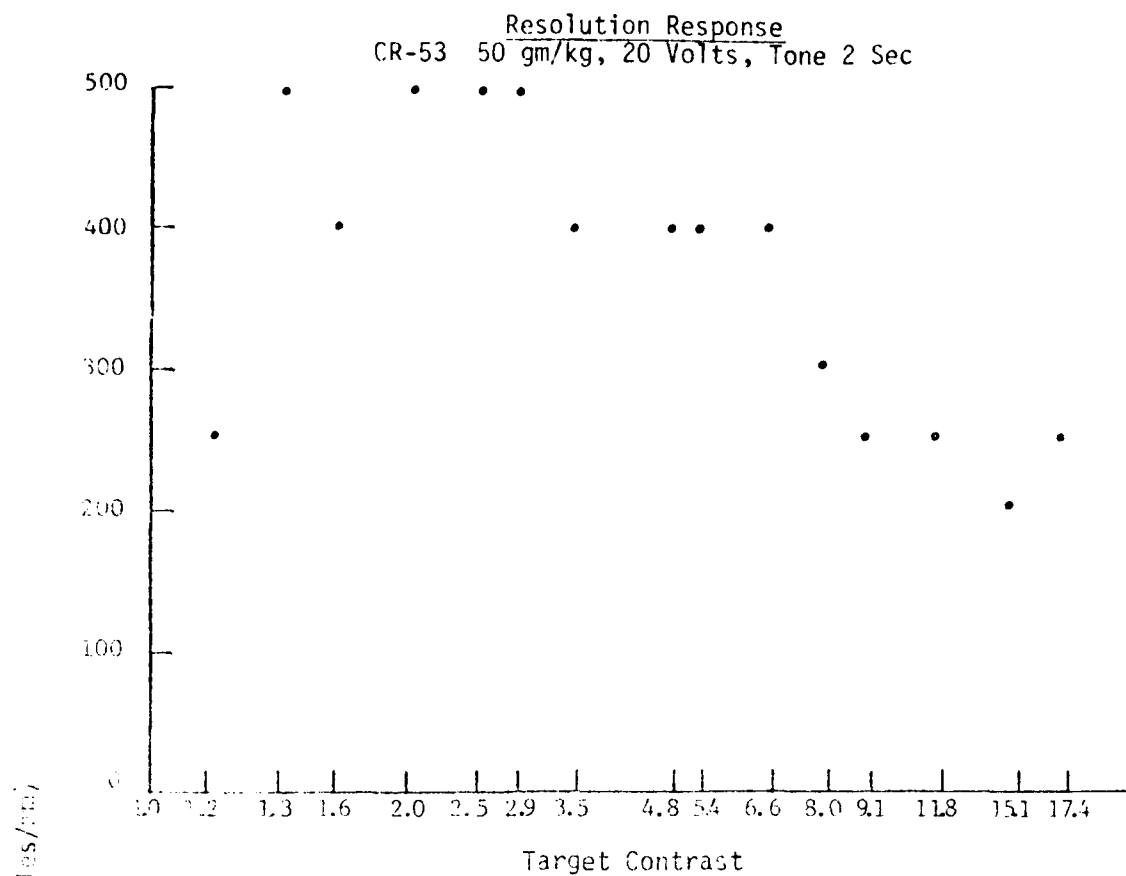


Figure 40



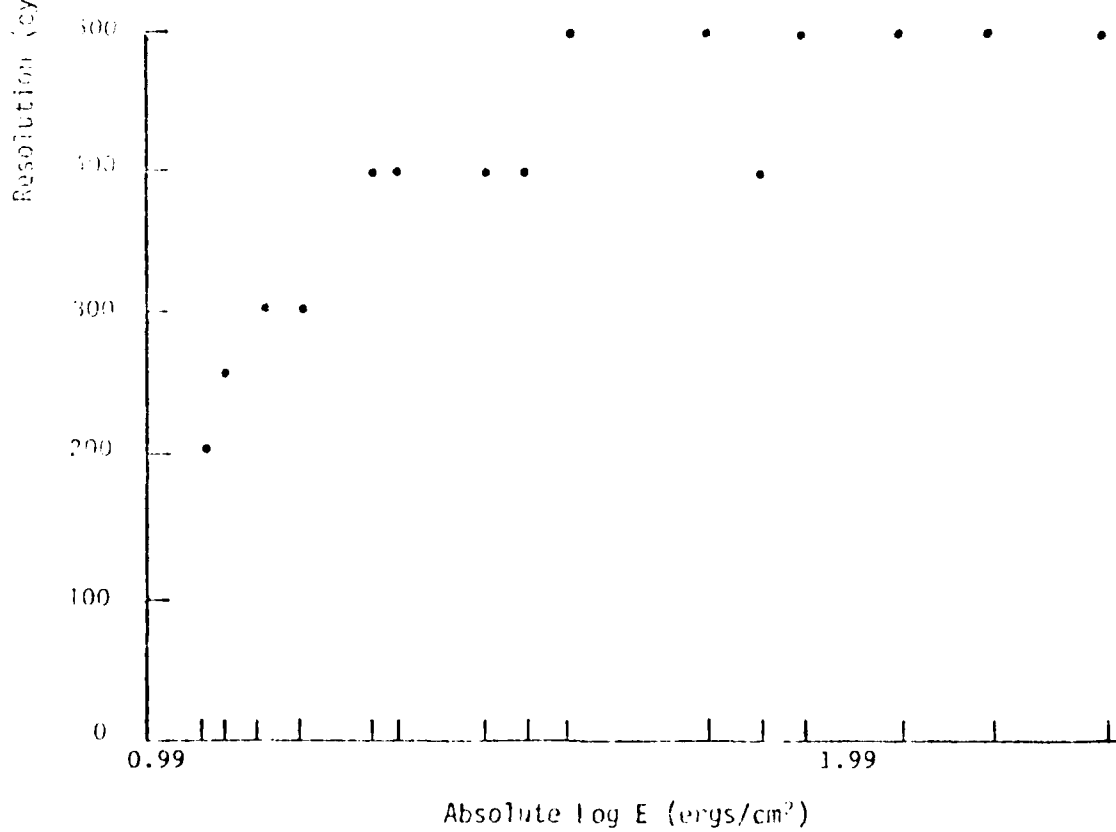
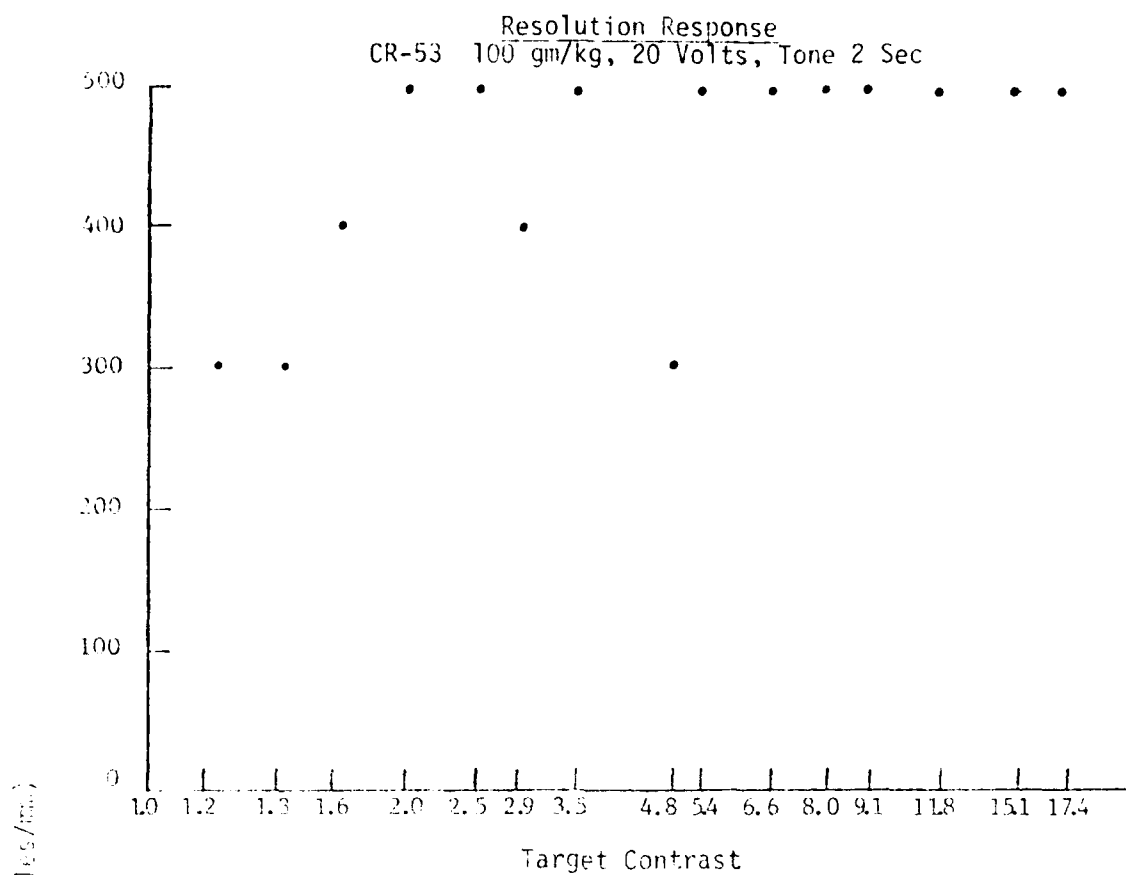


Figure 42

Resolution Response  
CR-53 100 gm/kg, 20 Volts, Tone 2 Sec.

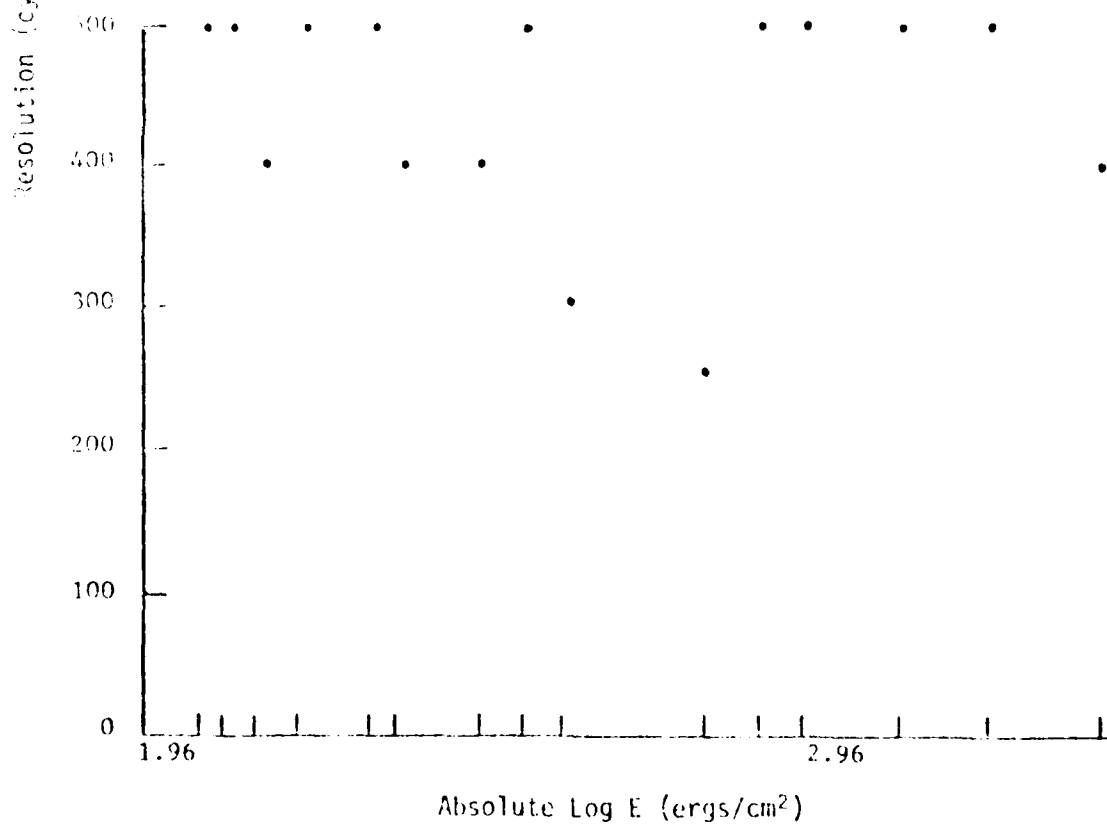
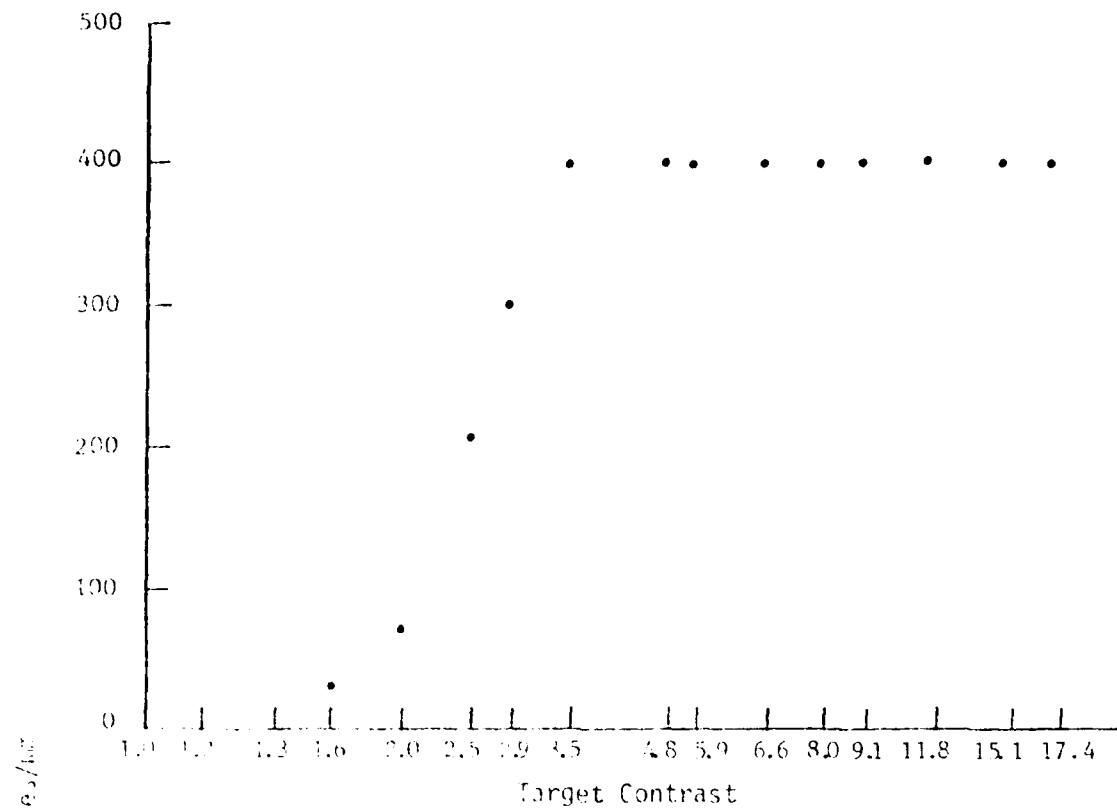


Figure 43

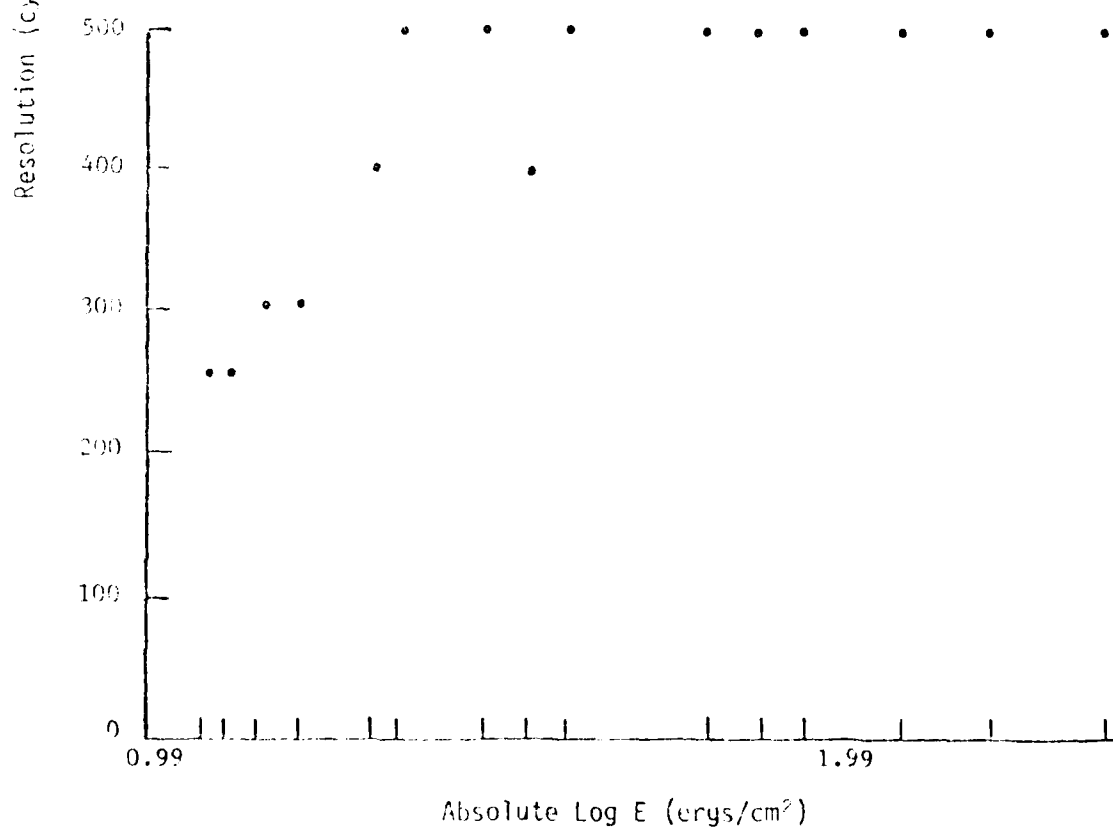
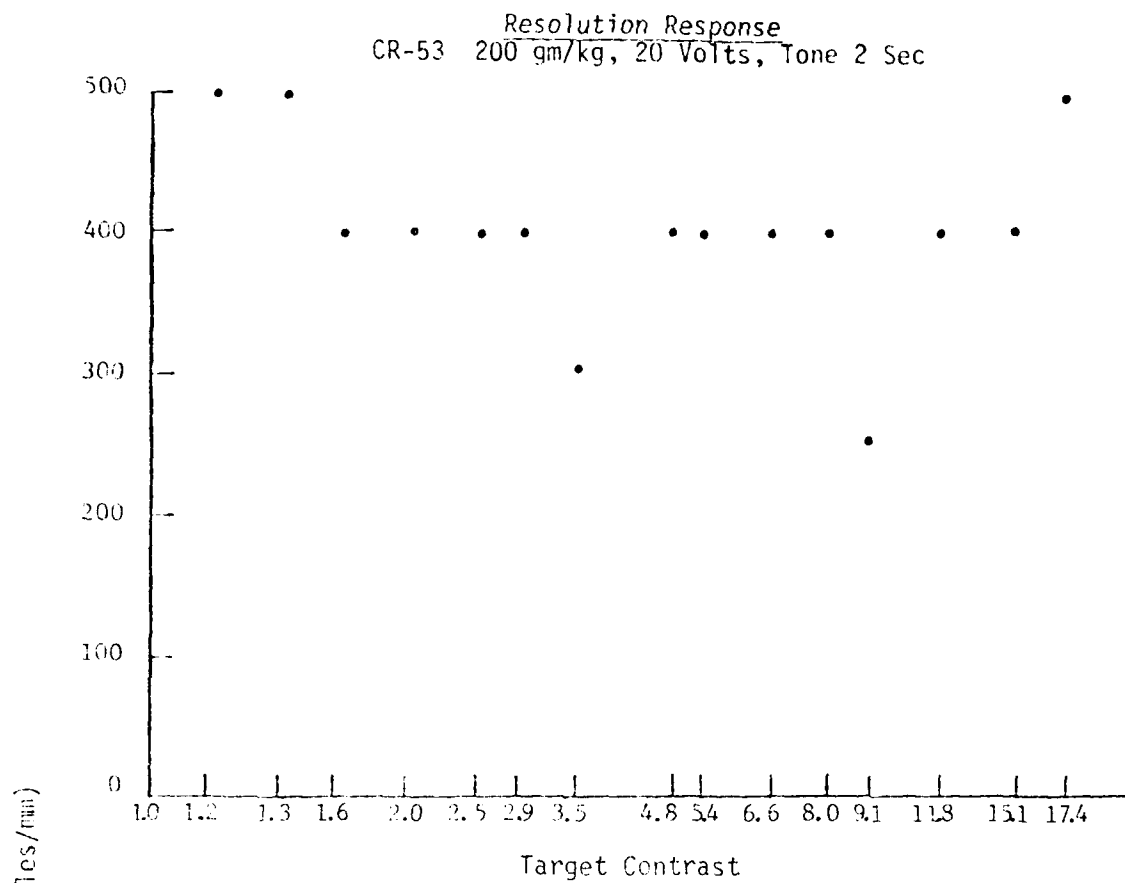


Figure 44

Resolution Response  
CR-53 200 gm/kg, 20 Volts, Tone 2 Sec.

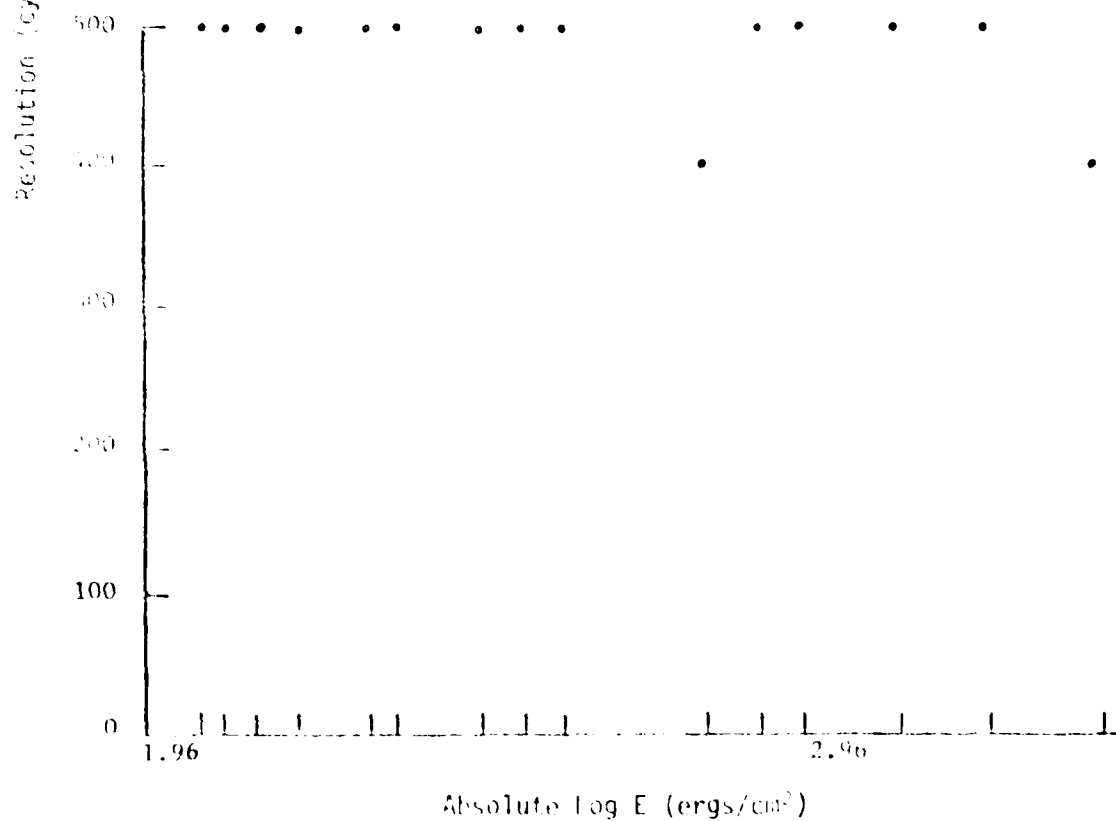
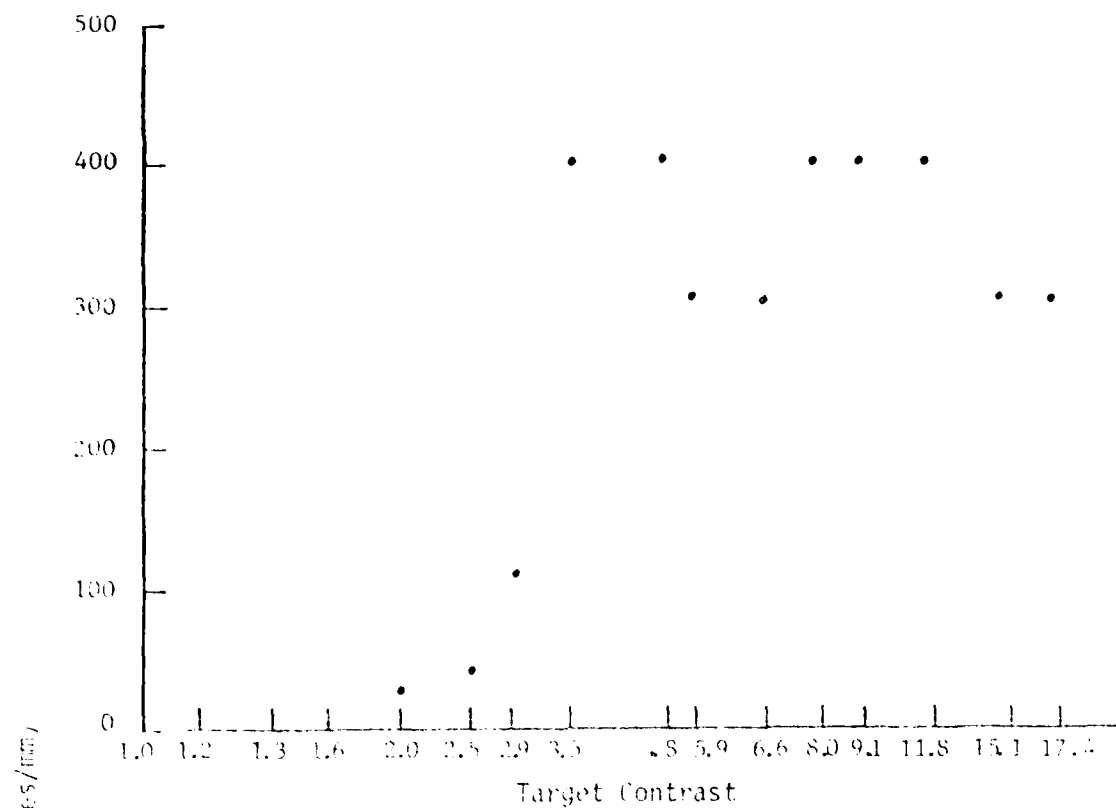


Figure 45

Resolution Response  
CR-53 50 gm/kg, 20 Volts, Tone 32 Sec.

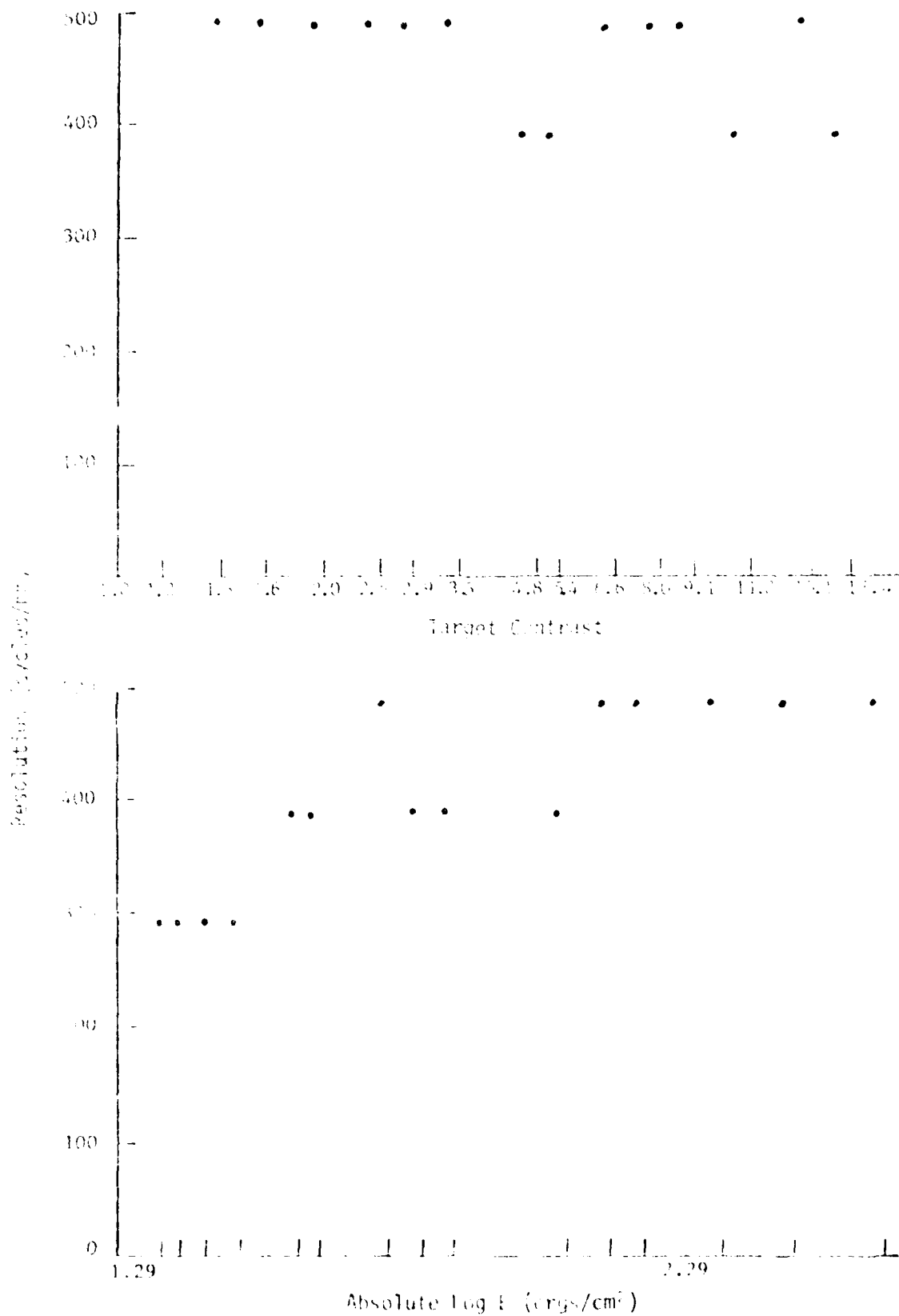


Figure 46

Resolution Response  
CR-55 50 gm/kg, 20 Volts, Tone 32 Sec.

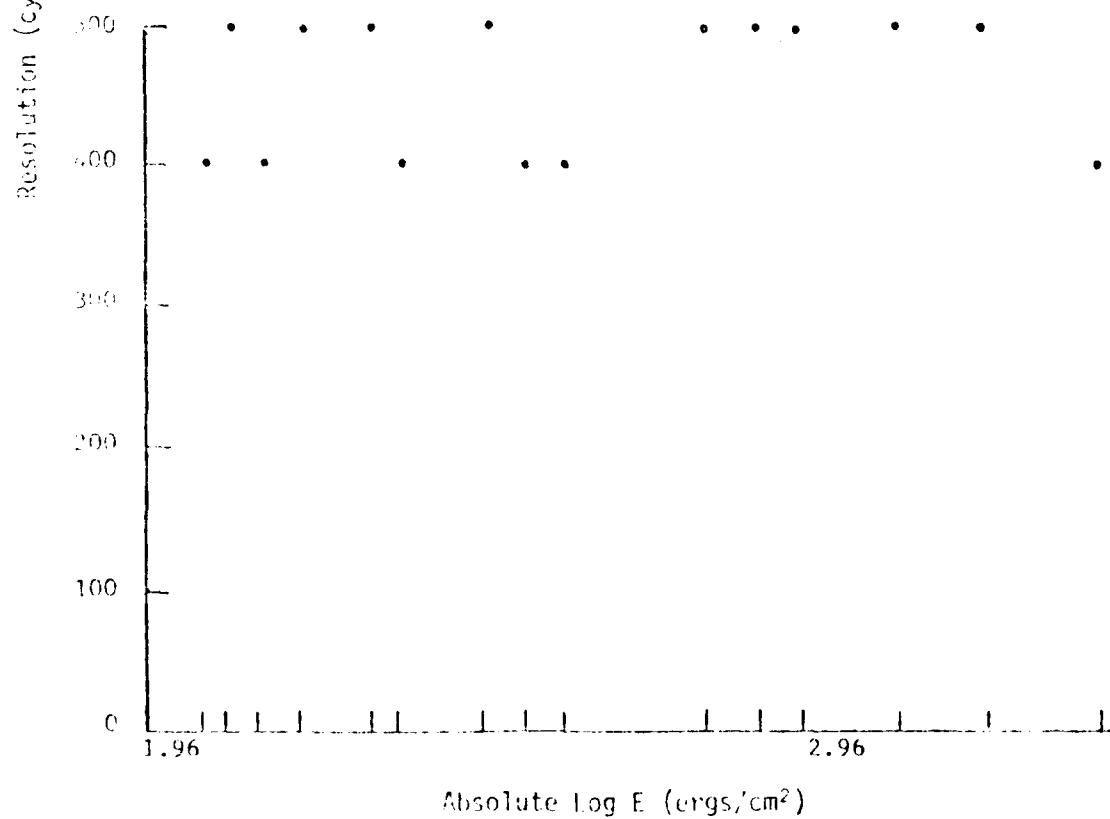
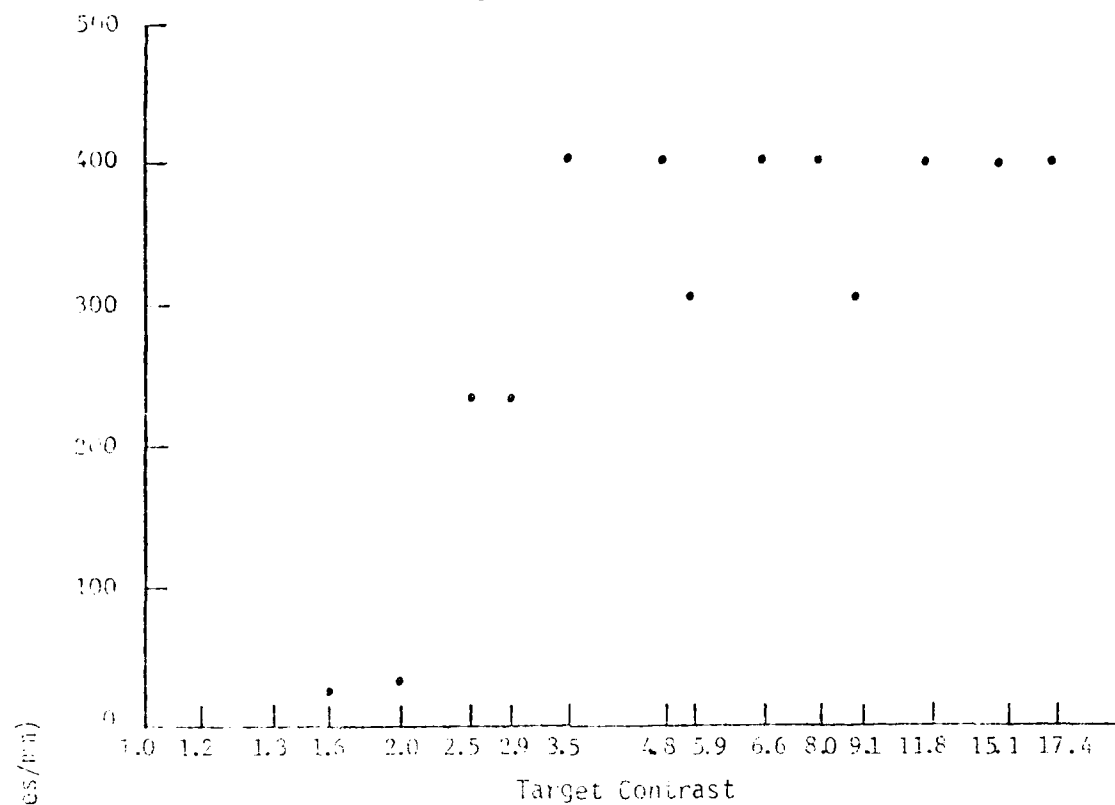


Figure 47

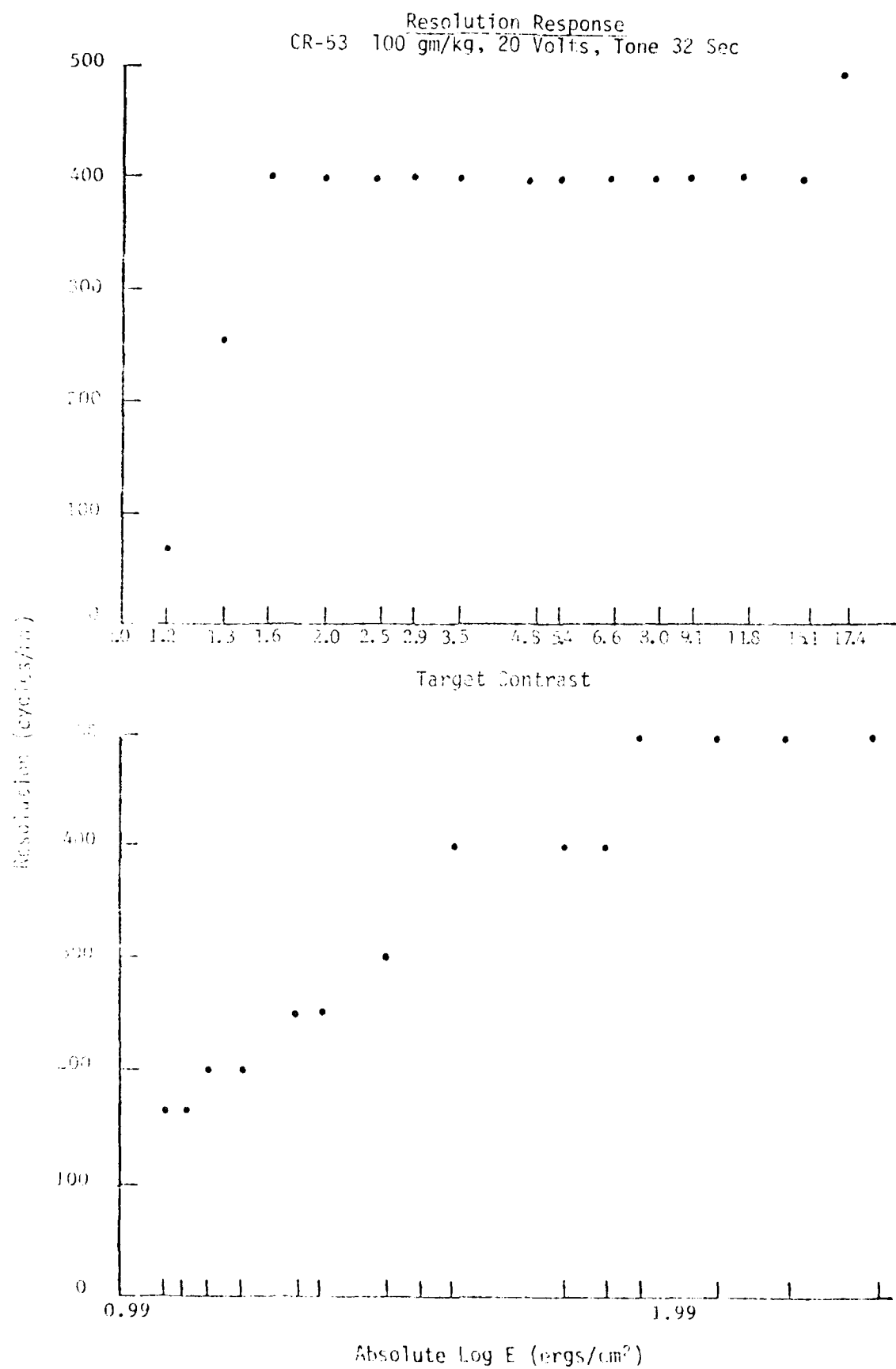


Figure 48

Resolution Response  
CR-53 100 m/kq, 20 Volts, Tone 32 Sec.

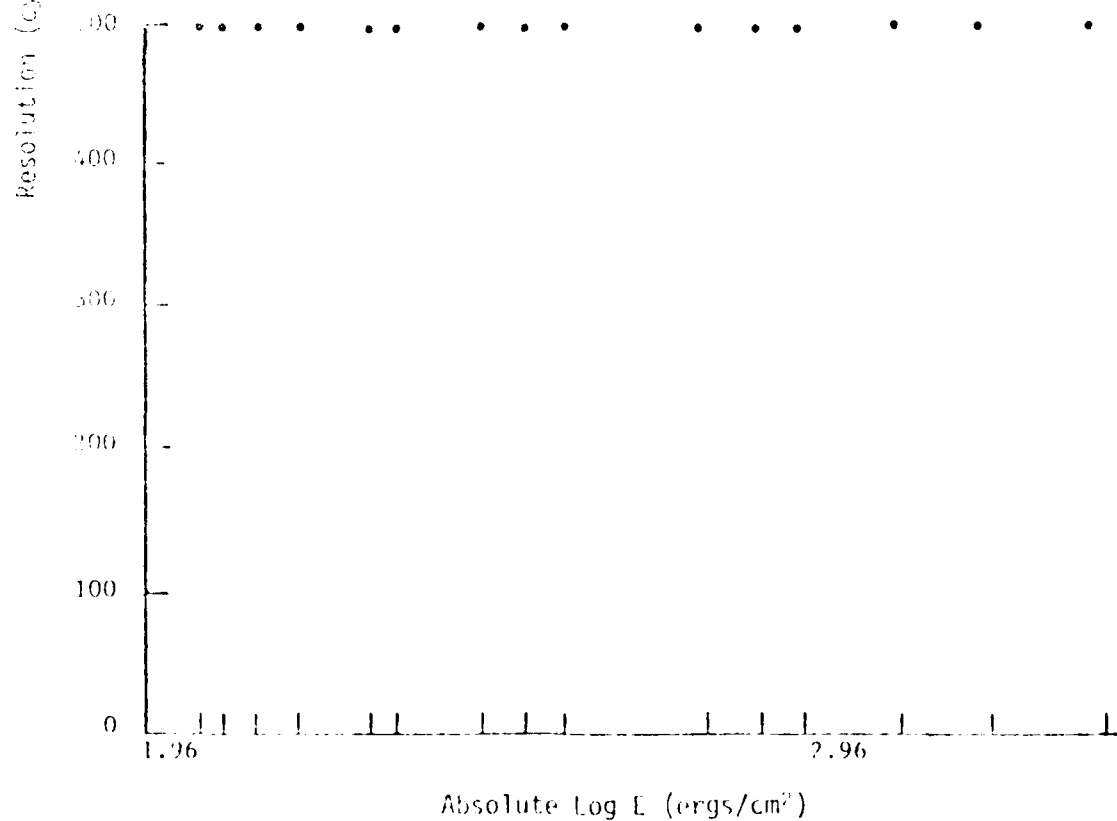
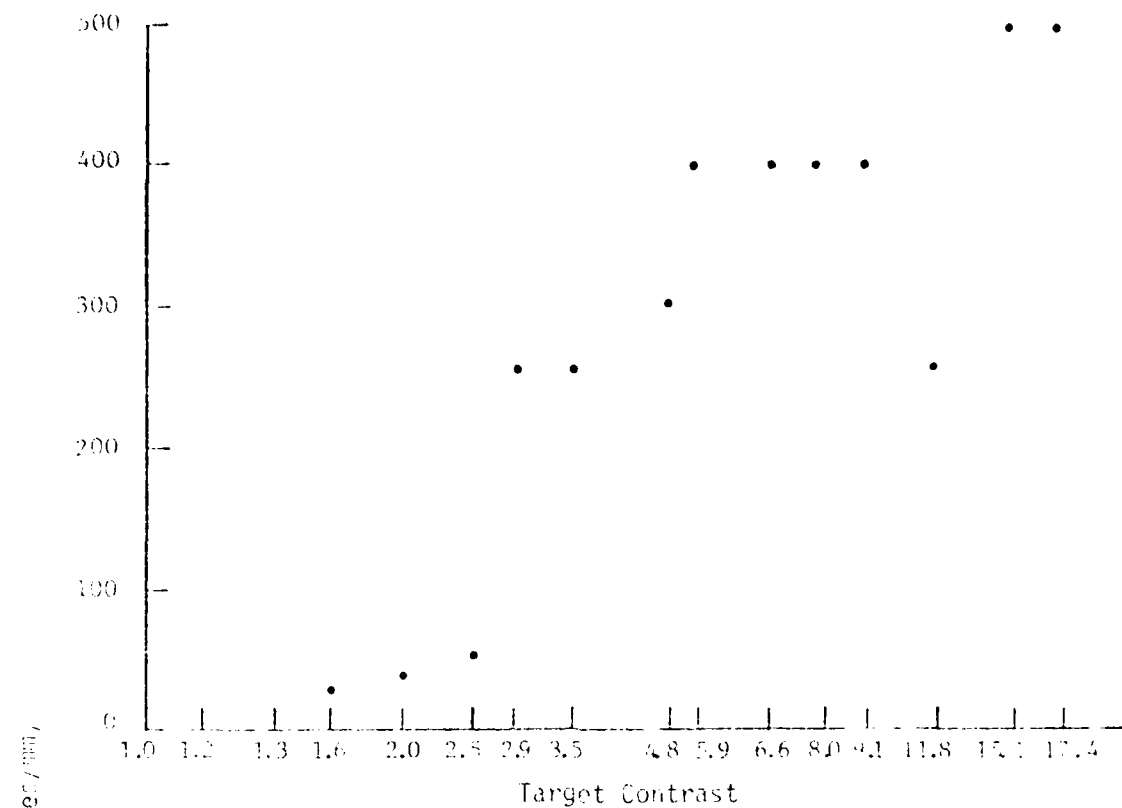


Figure 49

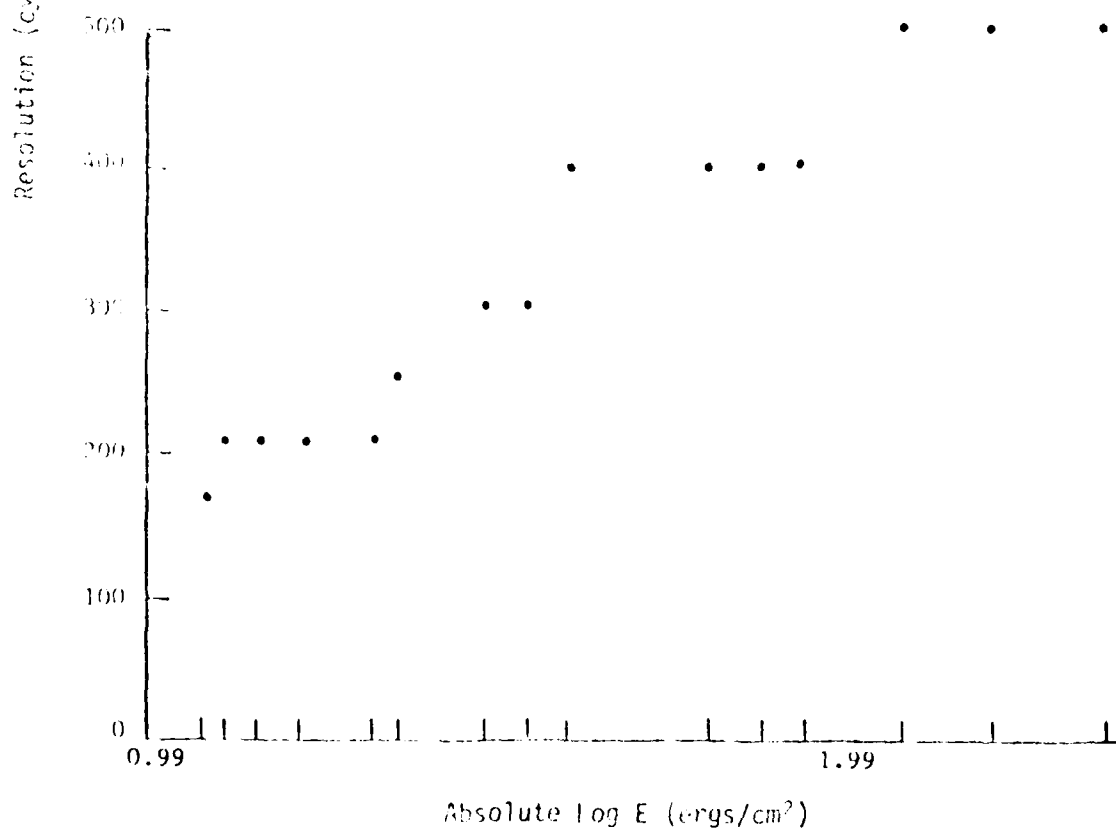
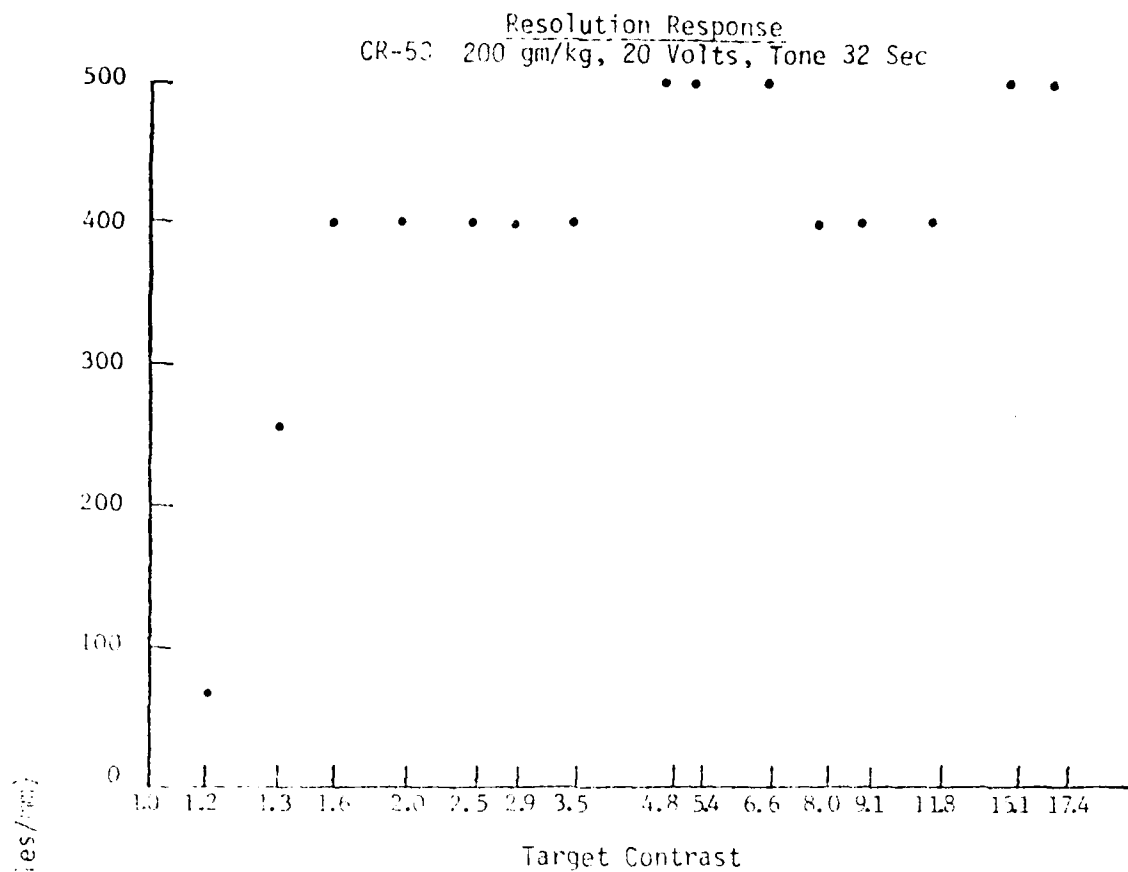


Figure 50

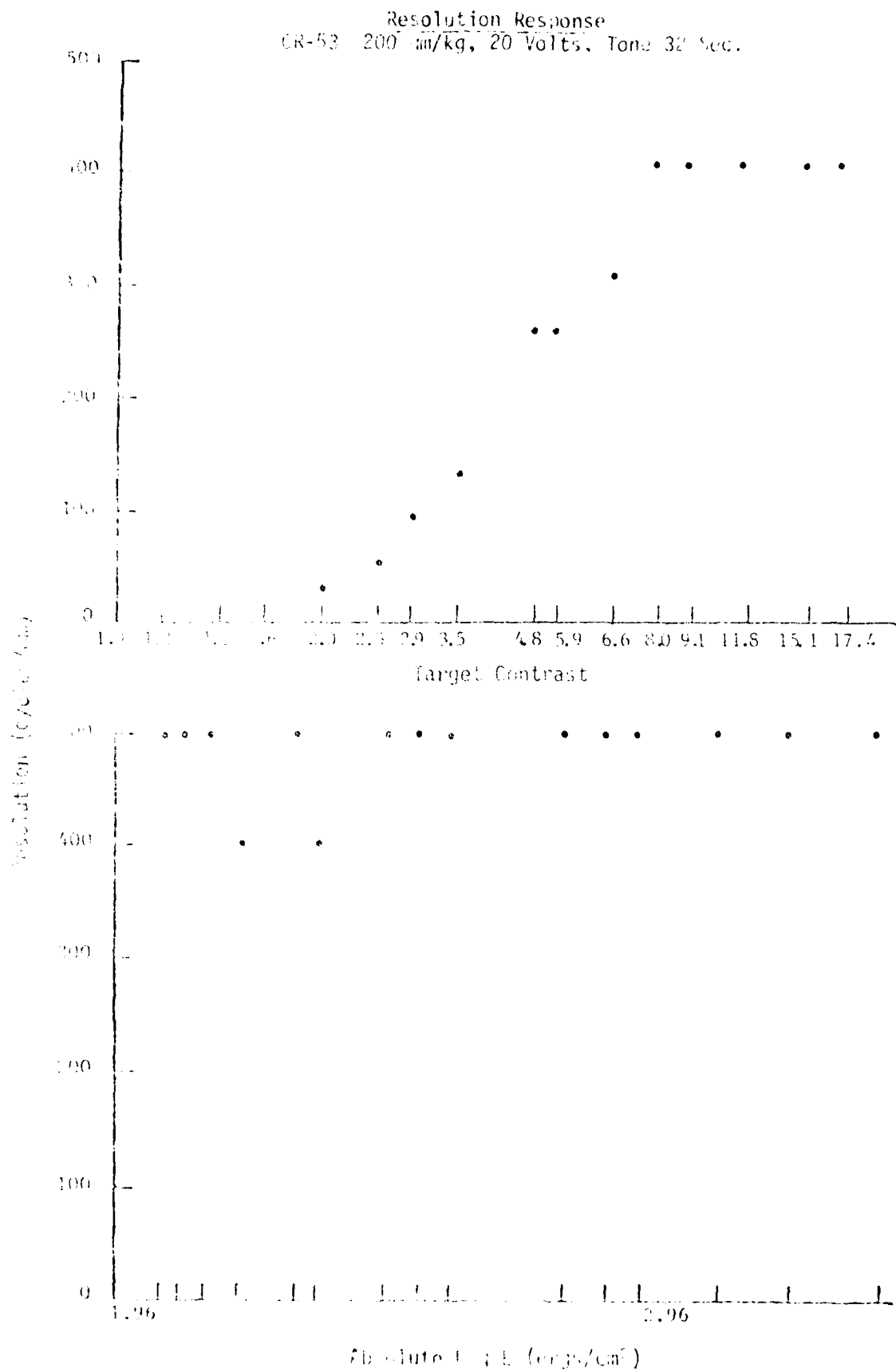


Figure 51

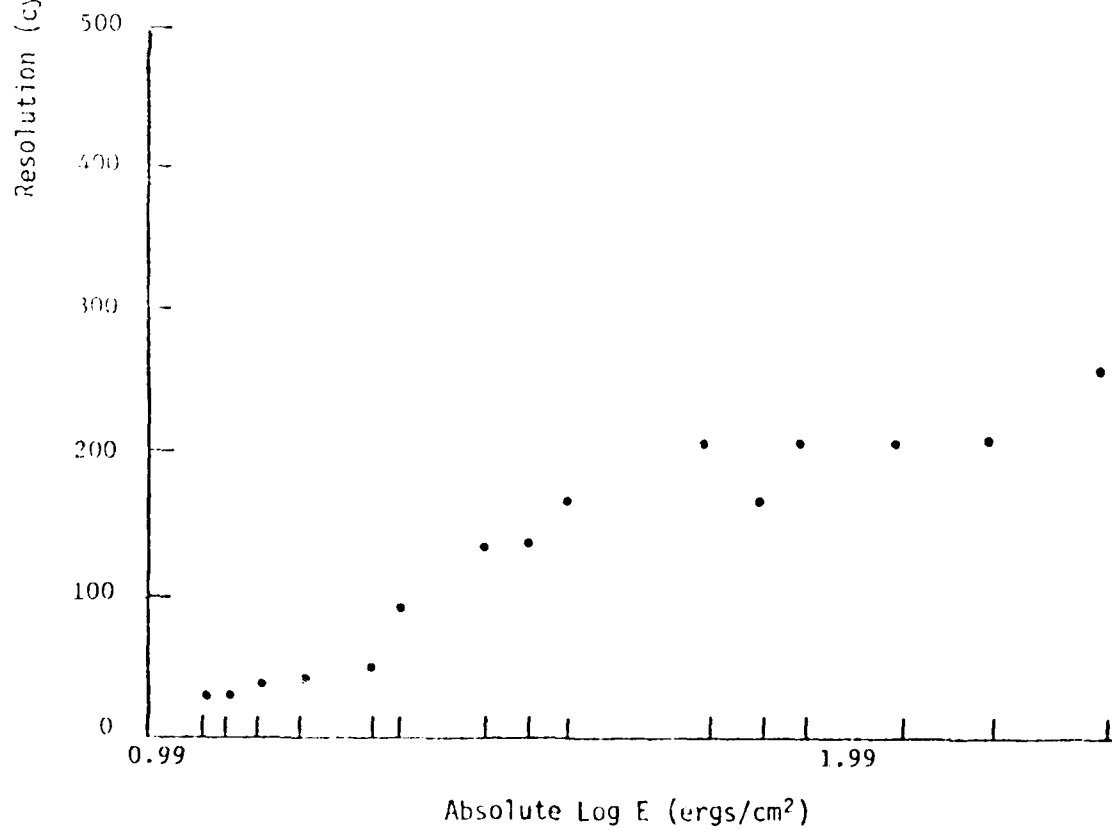
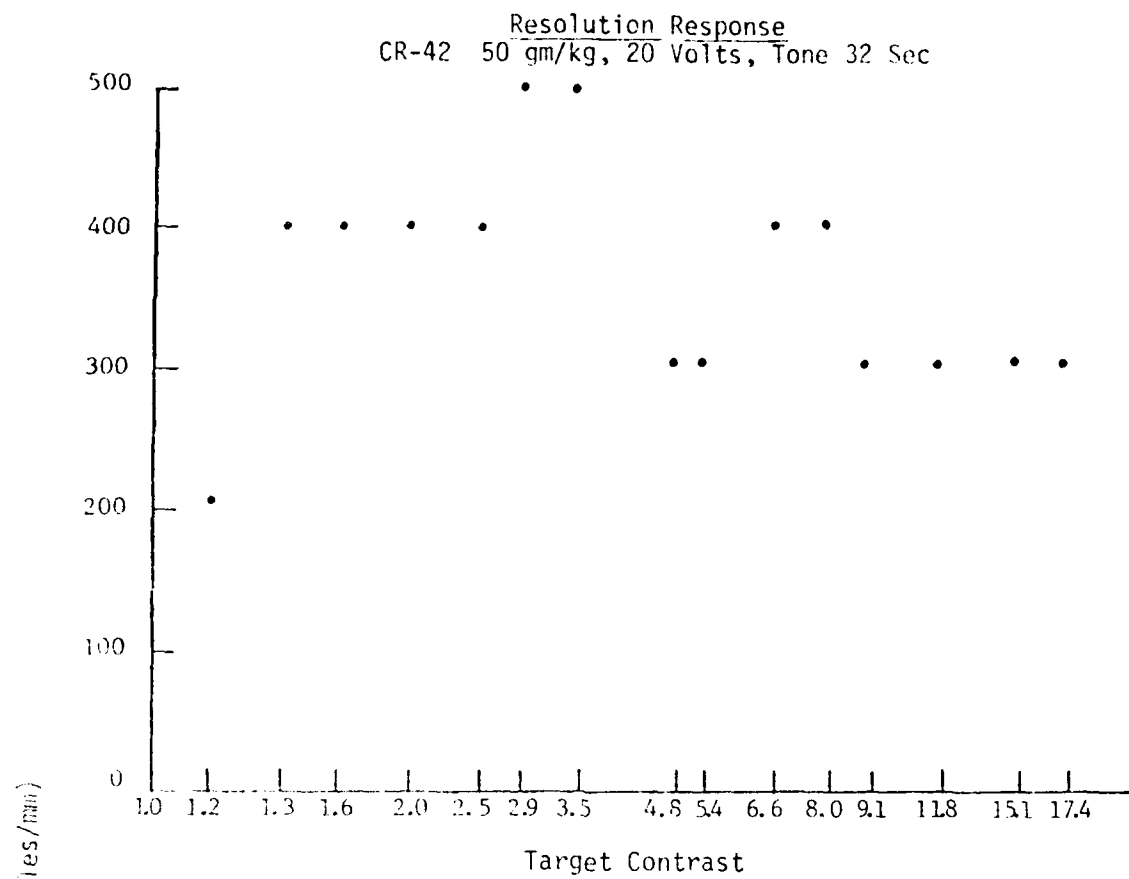


Figure 52

Resolution Response  
CR-42 50 gm/kg, 20 Volts, Tone 32 Sec.

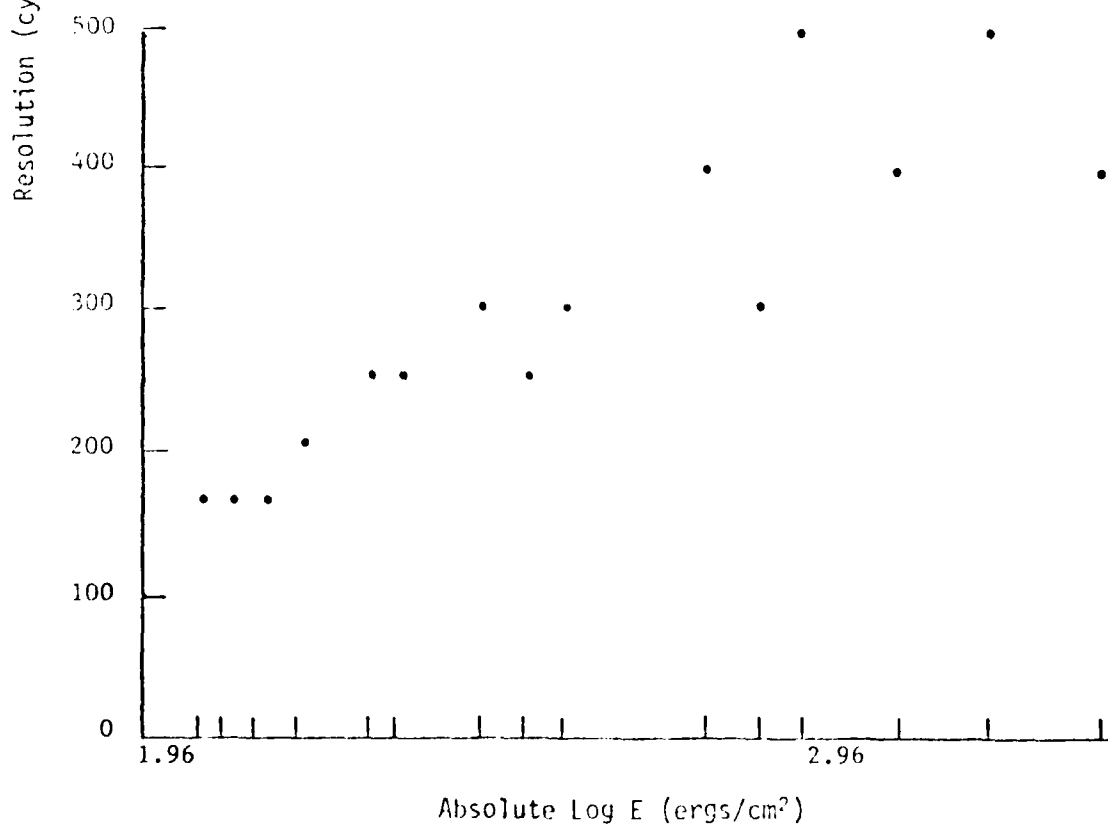
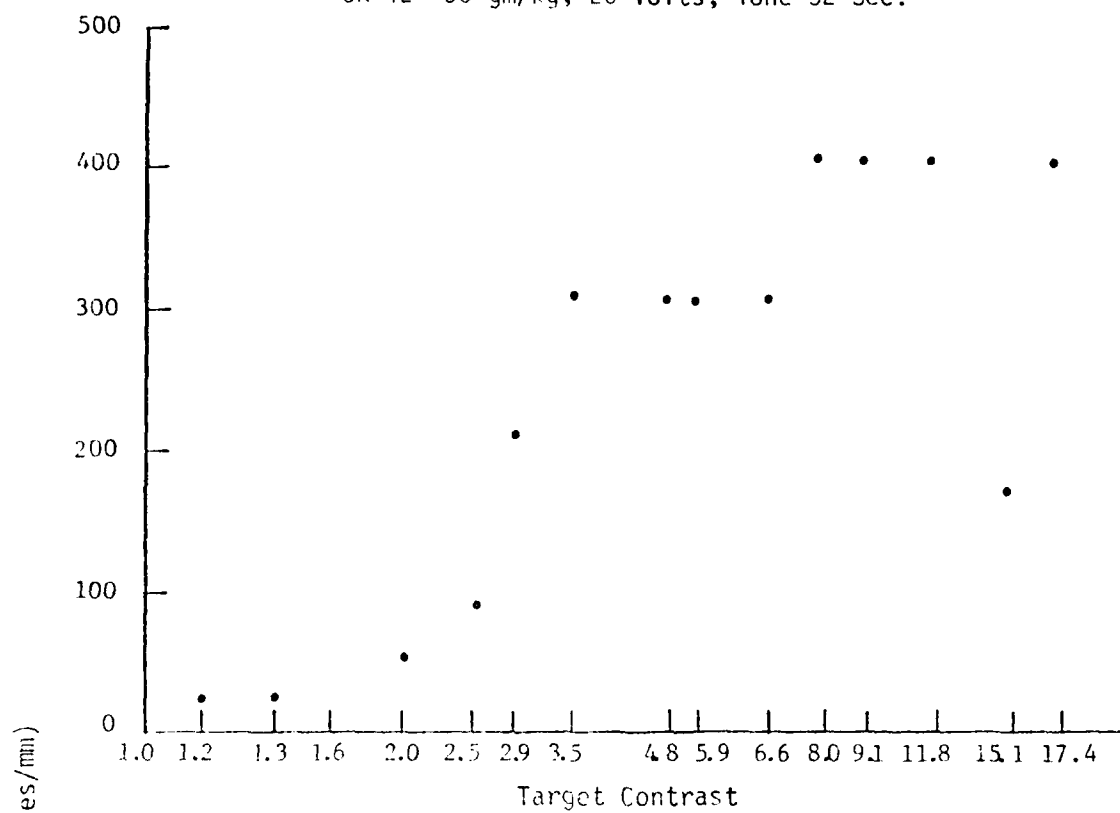


Figure 53

Resolution Response  
CR-42 50 gm/kg, 15 Volts, Tone 32 Sec.

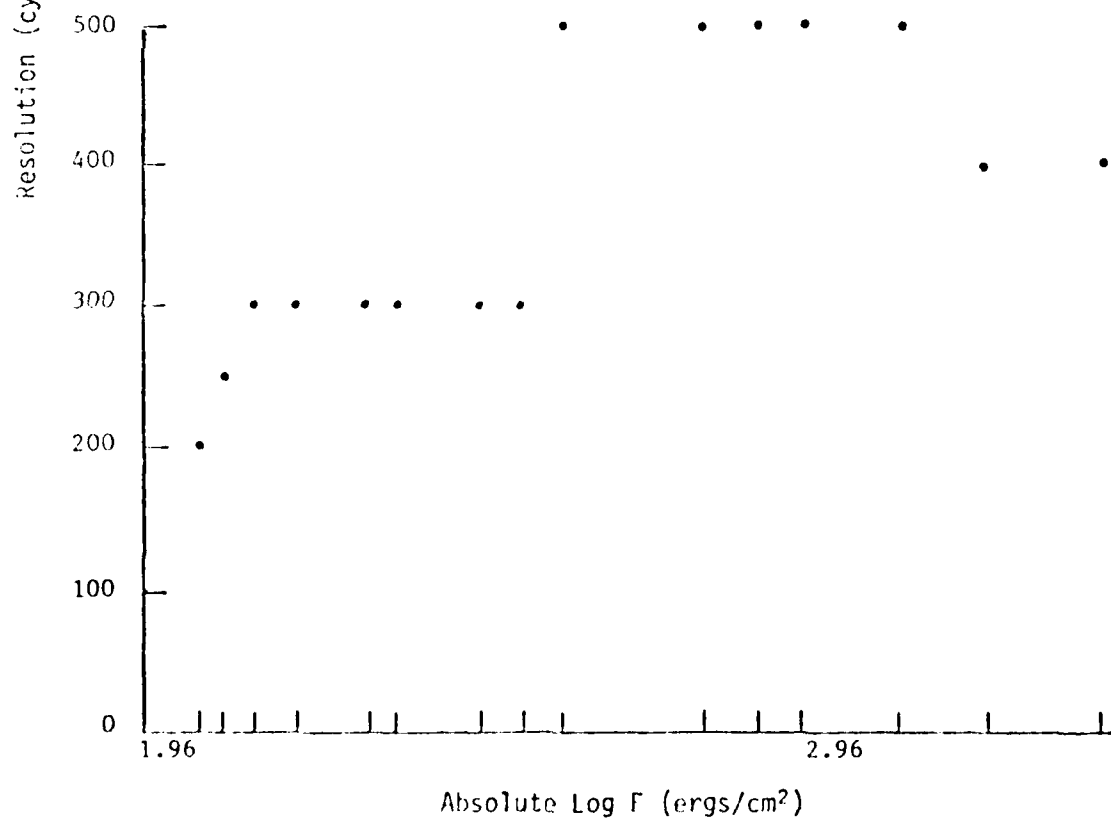
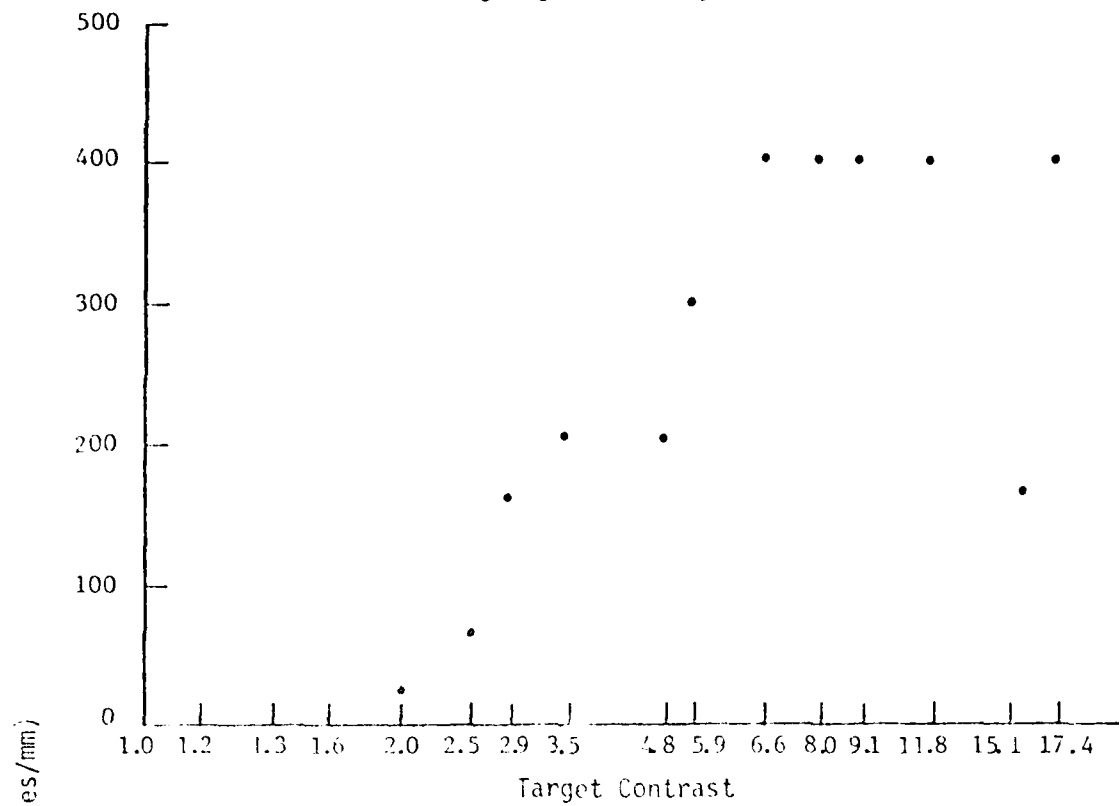
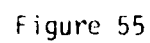


Figure 54

Target Contrast	CS/mm
2.0	20
2.5	30
3.0	20
3.5	70
4.8	110
5.9	130
6.0	170
8.0	170
9.1	260
11.8	310
15.1	310
17.4	310



CR-42 50 gm/kg, 5 Volts, Tone 32 Sec.

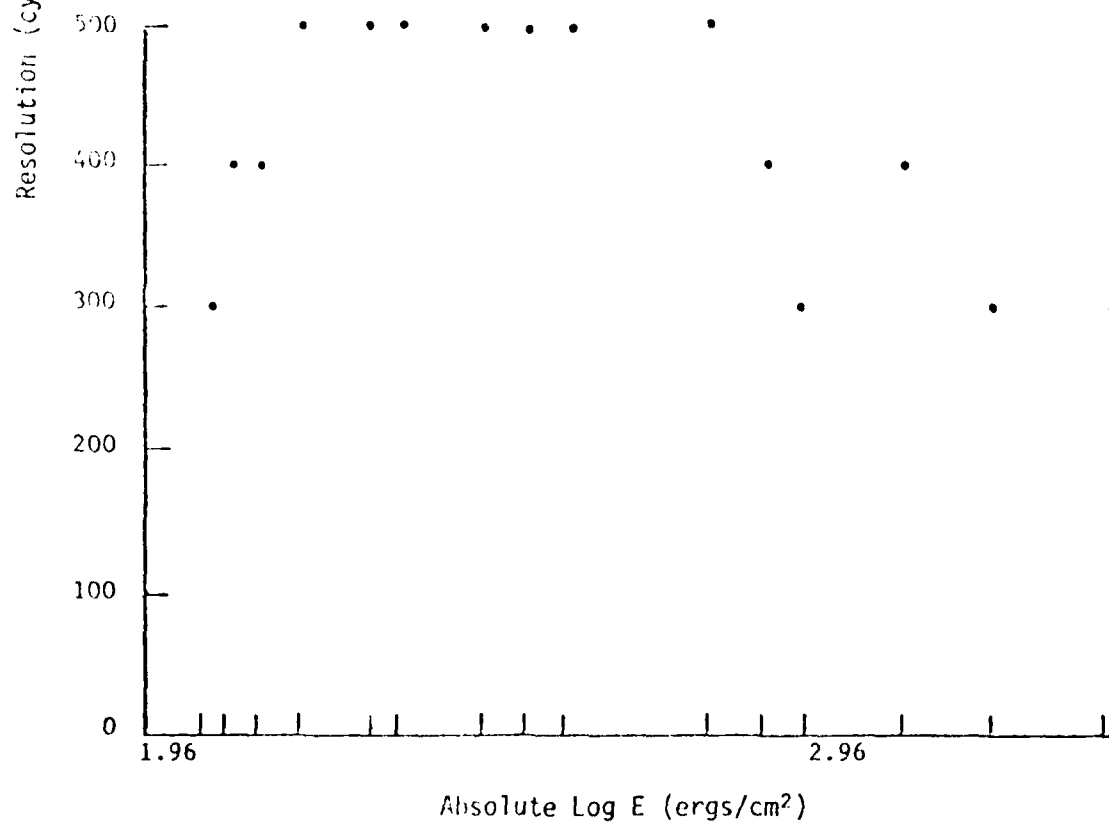
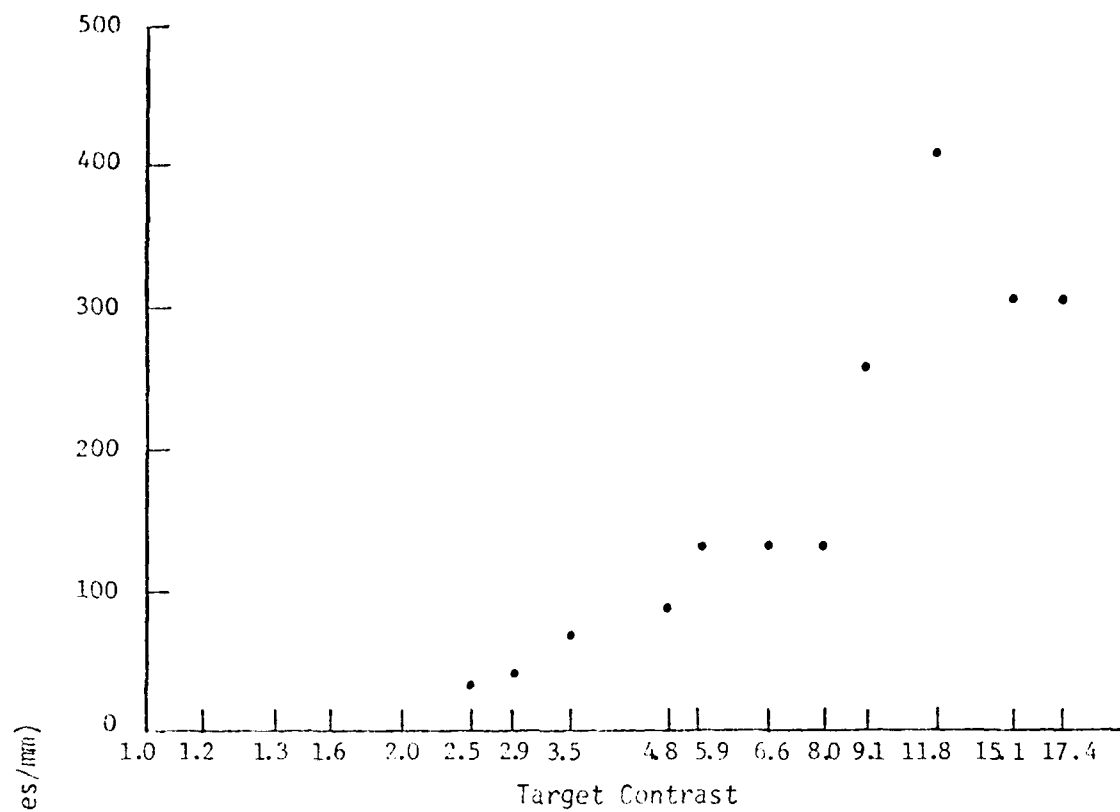


Figure 56

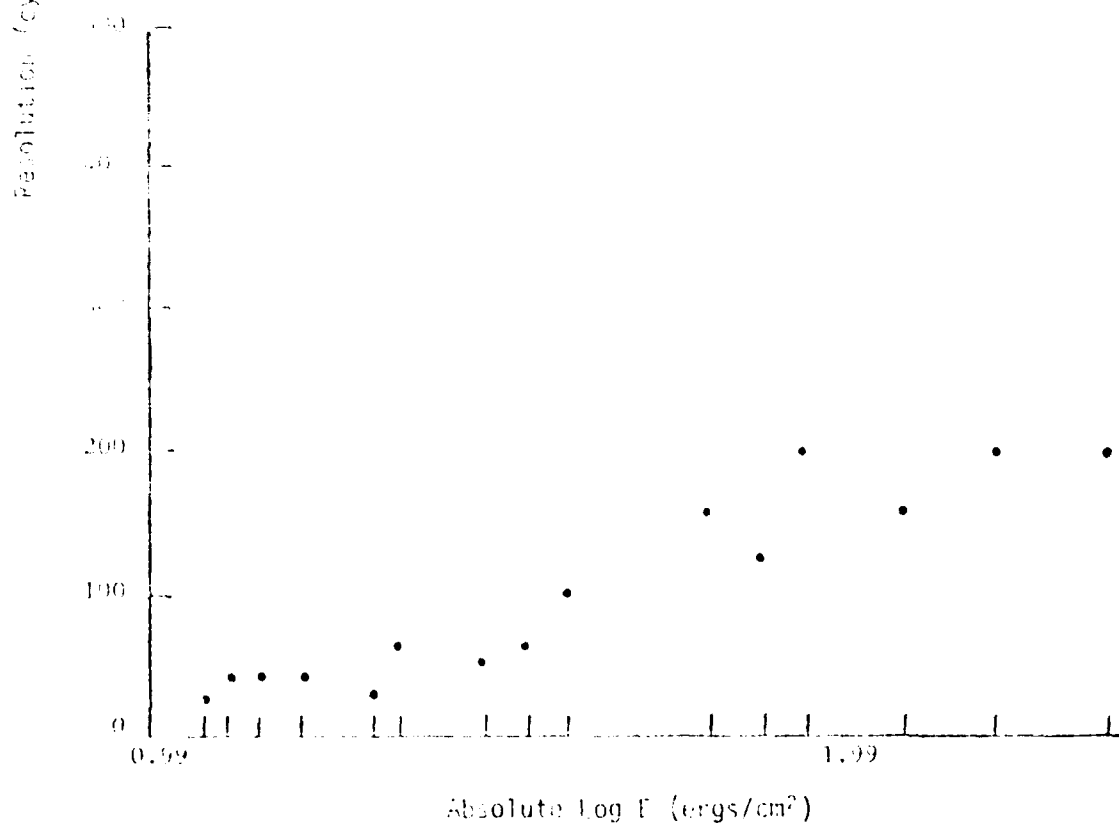
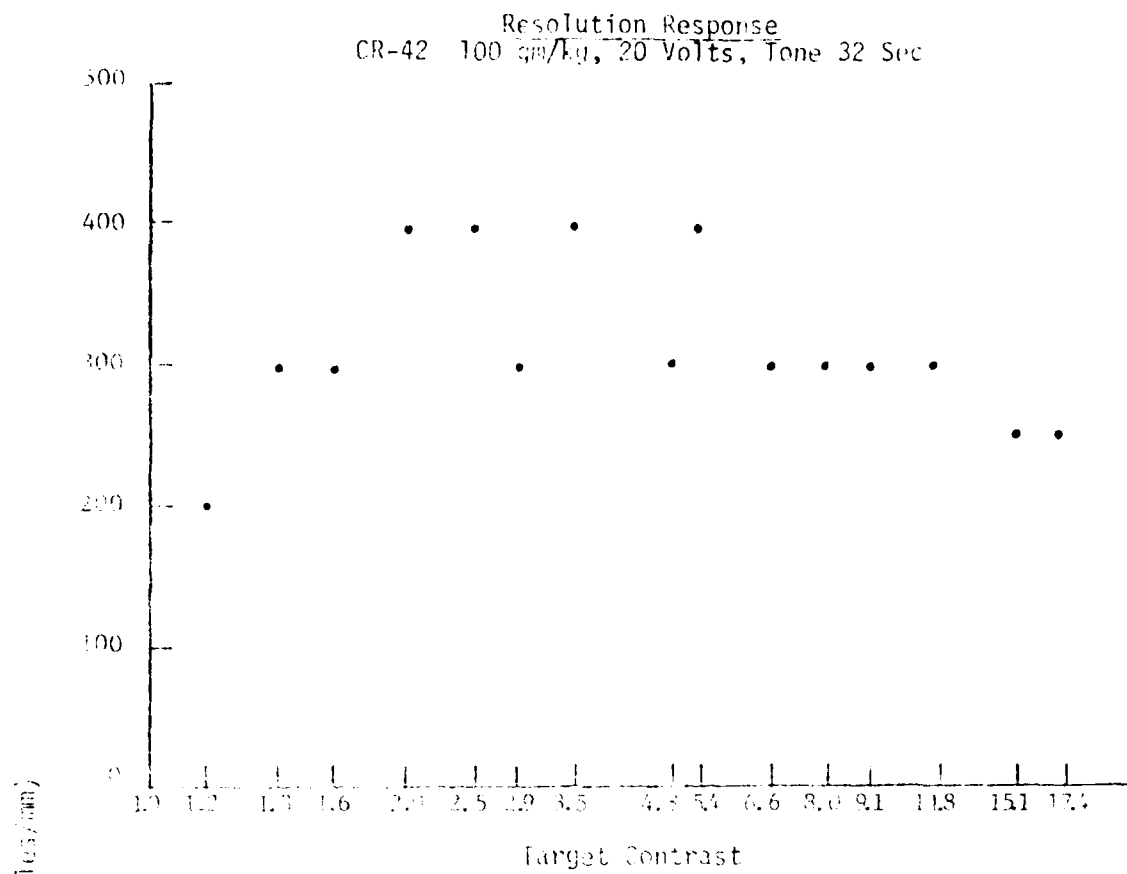


Figure 57

Resolution Response  
CR-42 100 gm/kg, 20 Volts, Tone 32 Sec.

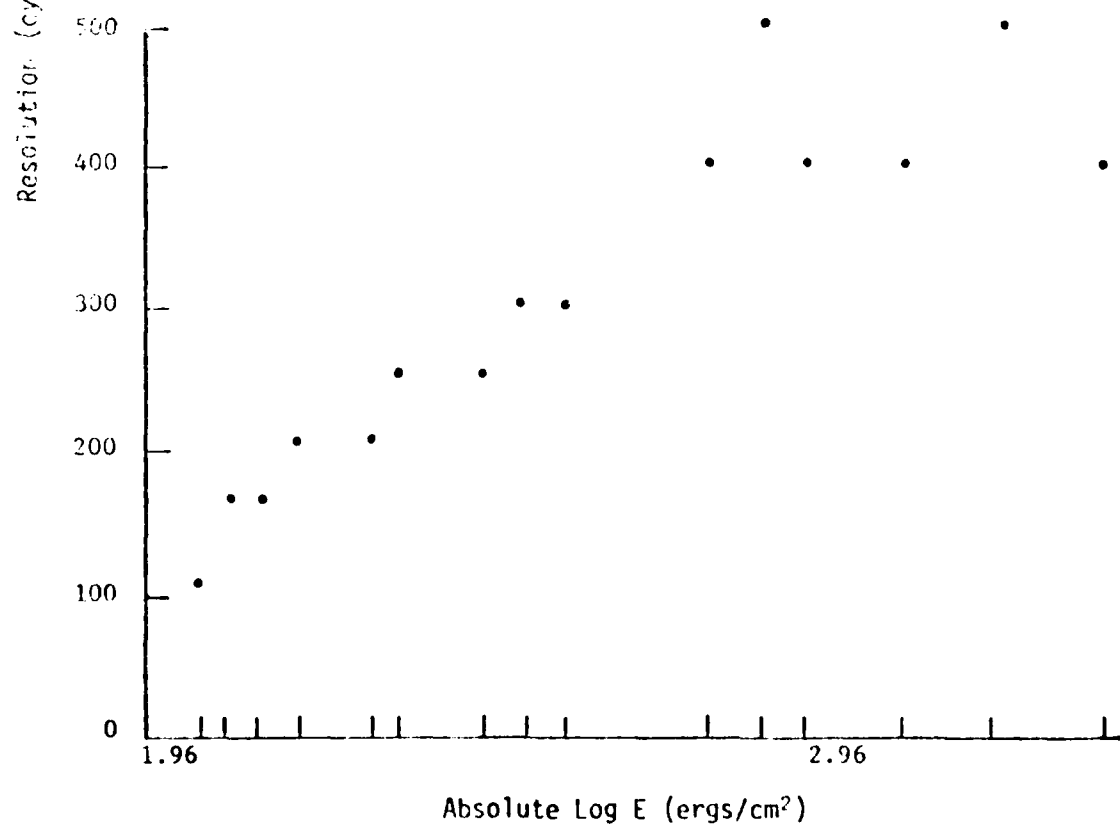
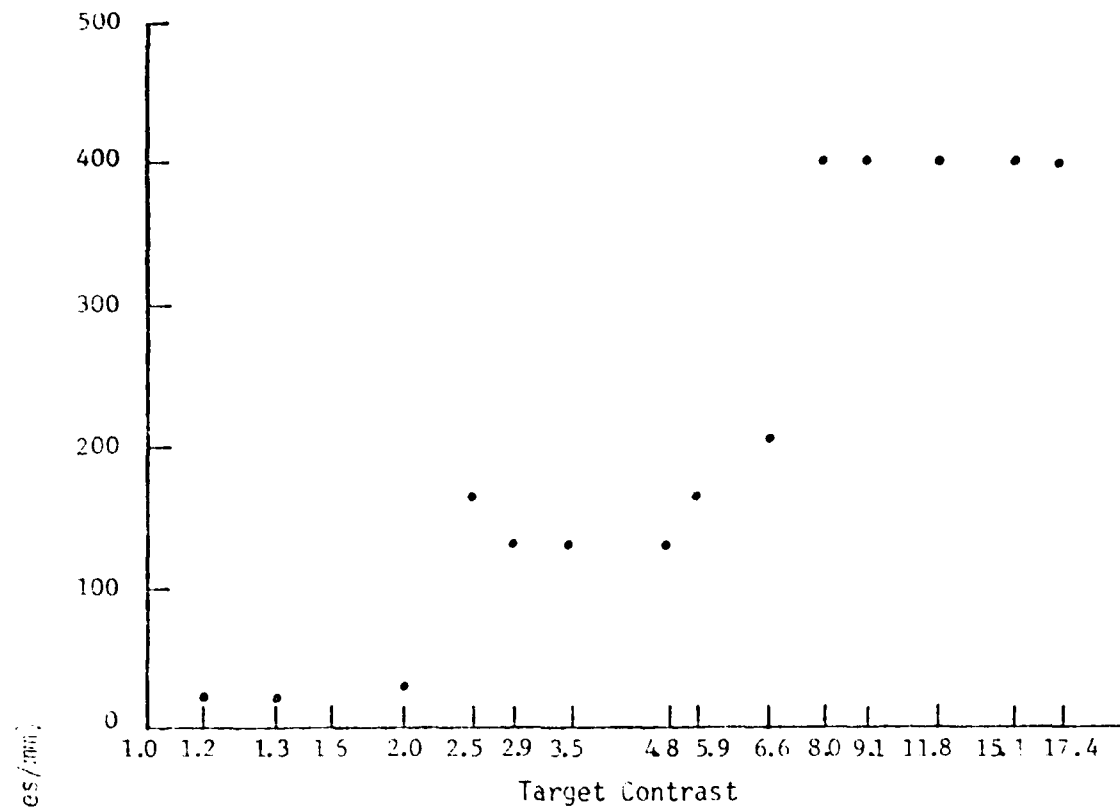


Figure 58

Resolution Response  
CR-42 100 gm/kg, 15 Volts, Tone 32 Sec.

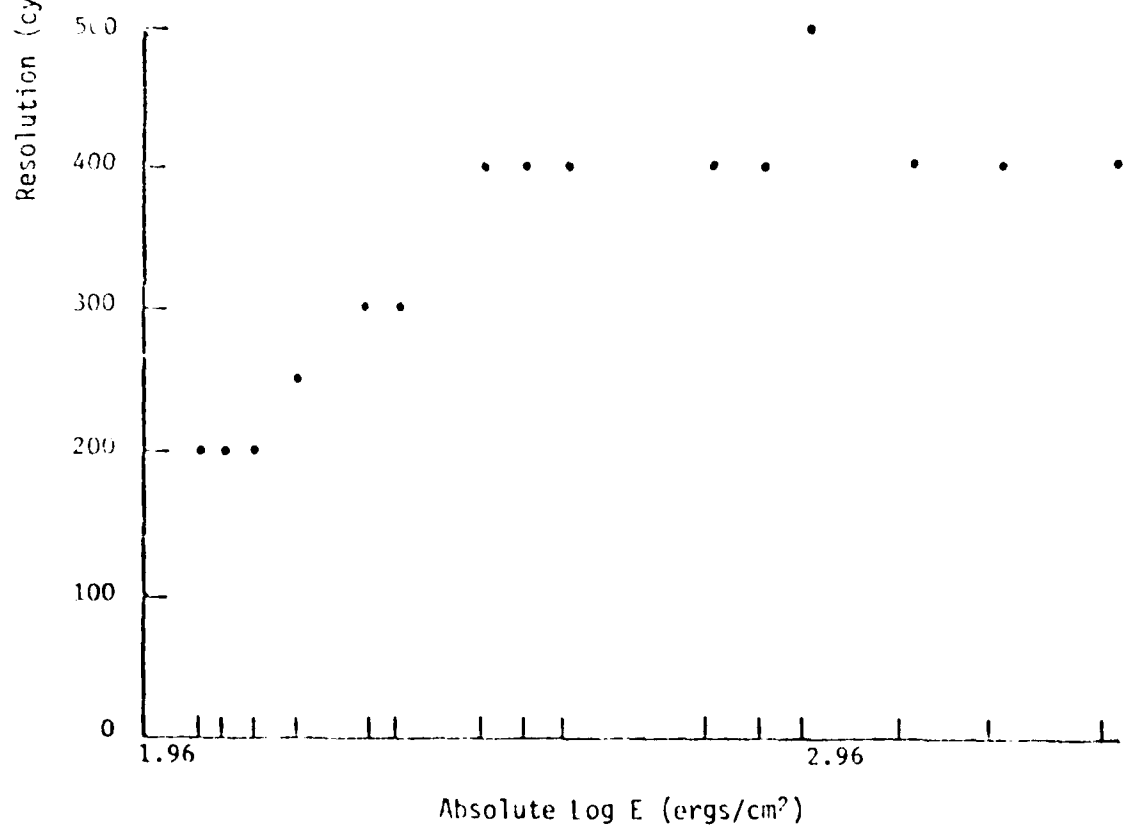
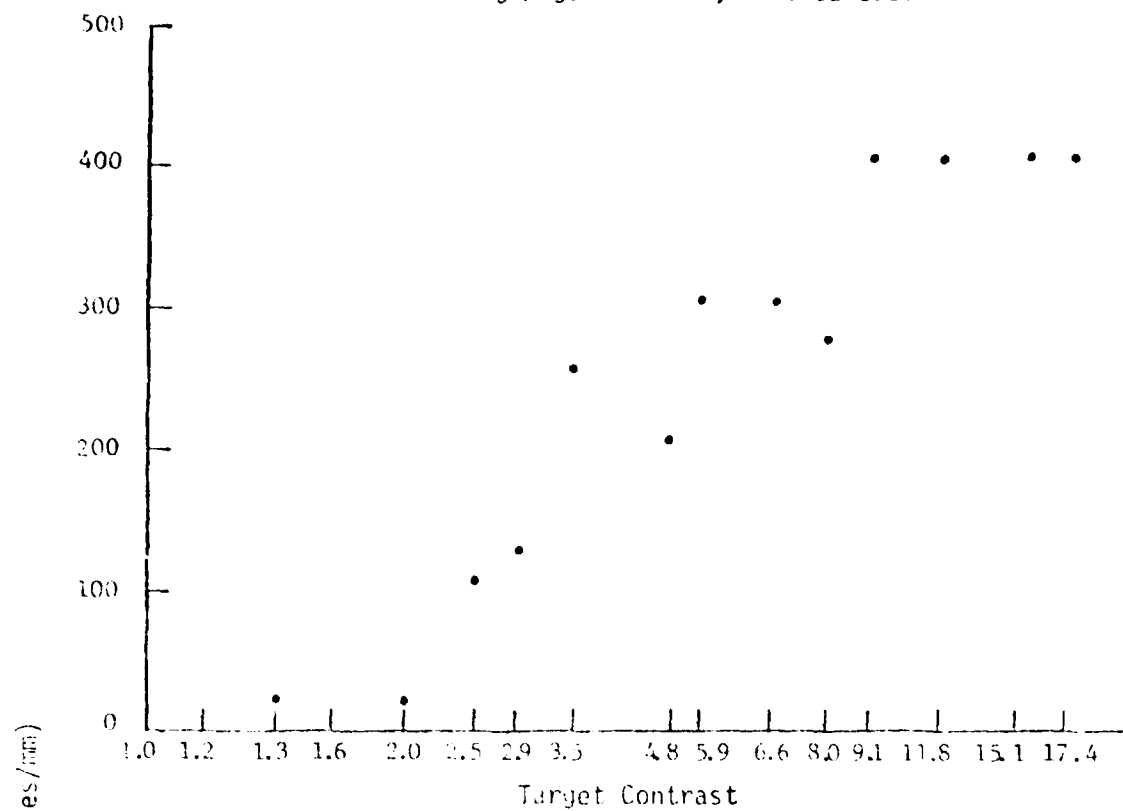


Figure 59

Resolution Response  
CR-42 100 gm/kg, 10 Volts, 10 sec 32 Sec

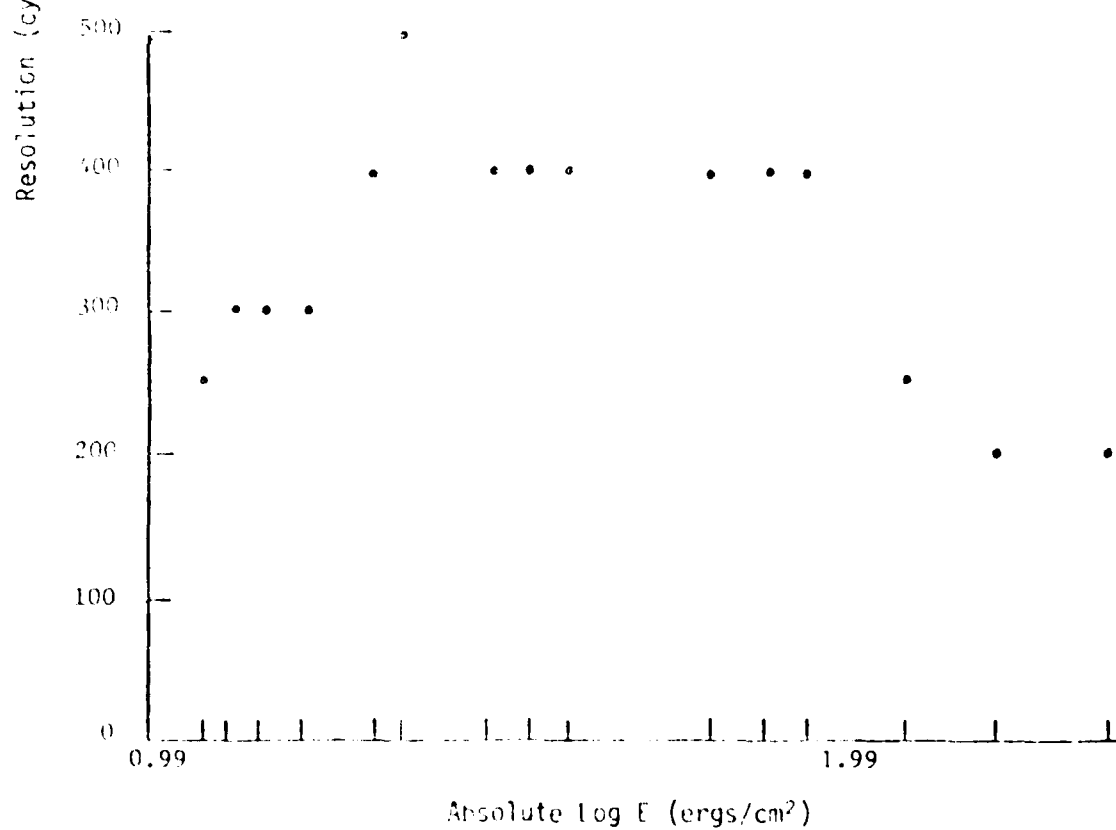
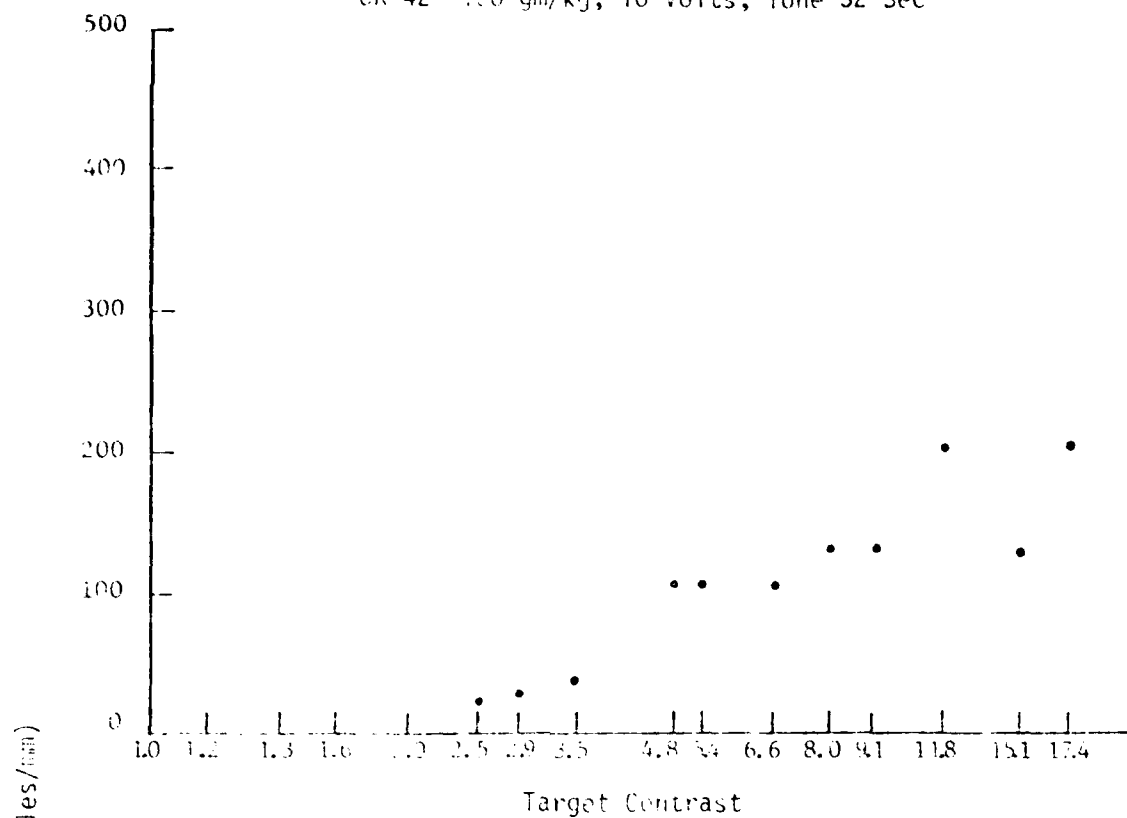


Figure 60

Resolution Response  
CR-42 100 gm/kg, 5 Volts, Tone 32 Sec.

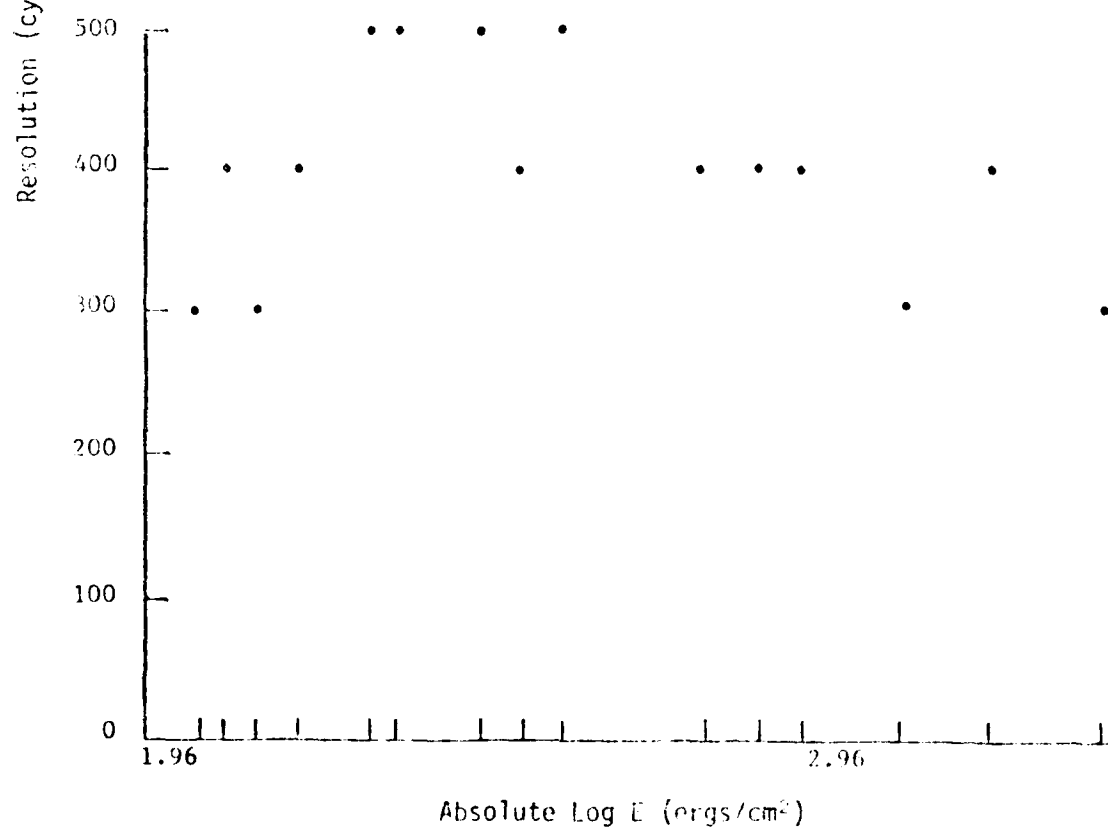
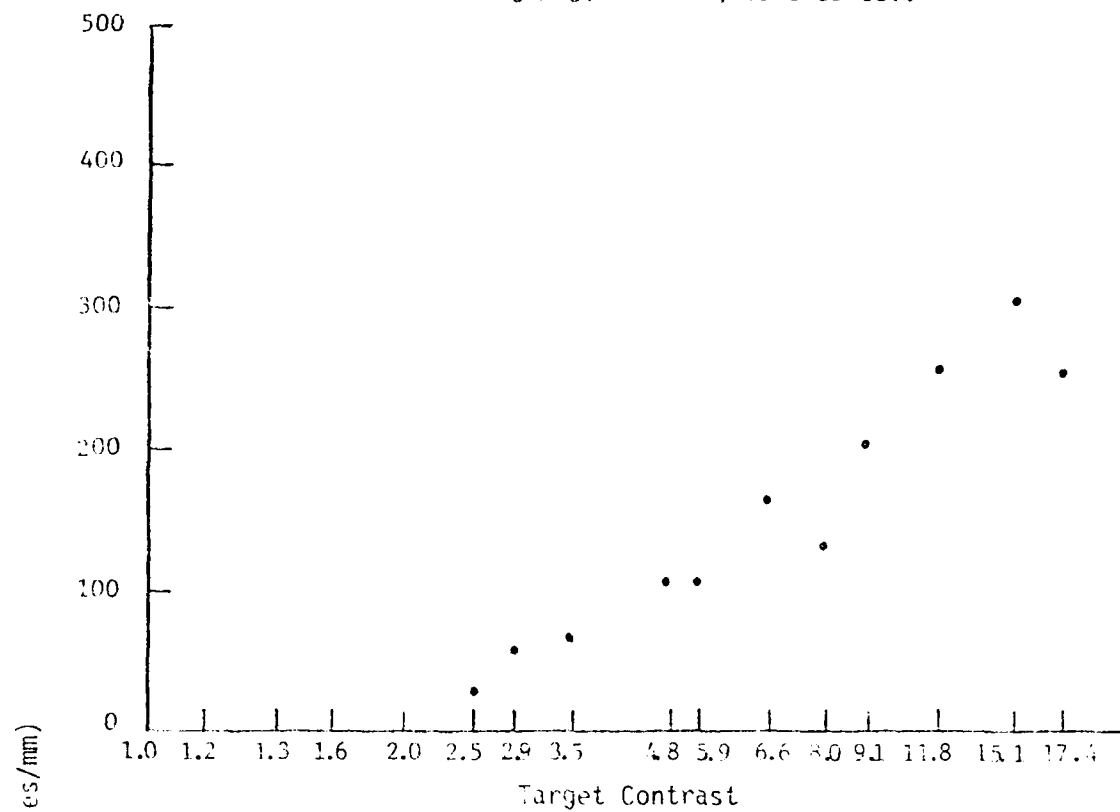
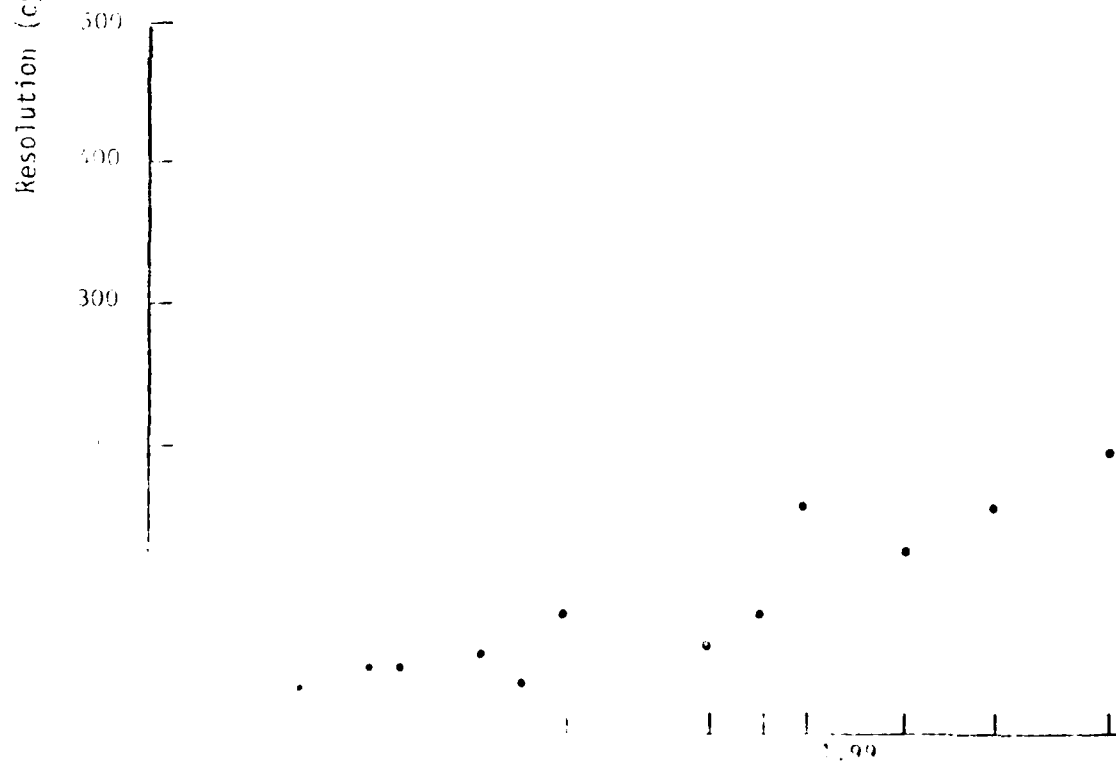
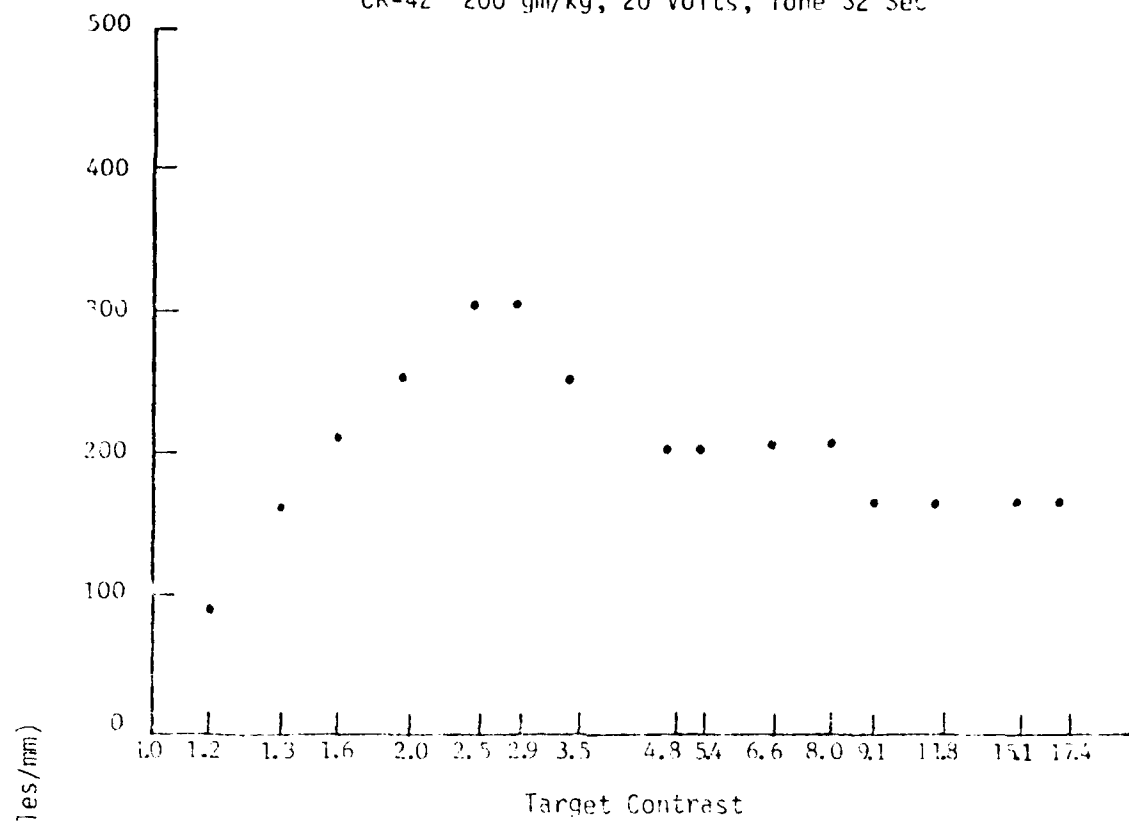


Figure 61

Resolution Response  
CR-42 200 gm/kg, 20 Volts, Tone 32 Sec



Resolution Response  
CR-42 200 gm/kg, 20 Volts, Tone 32 Sec

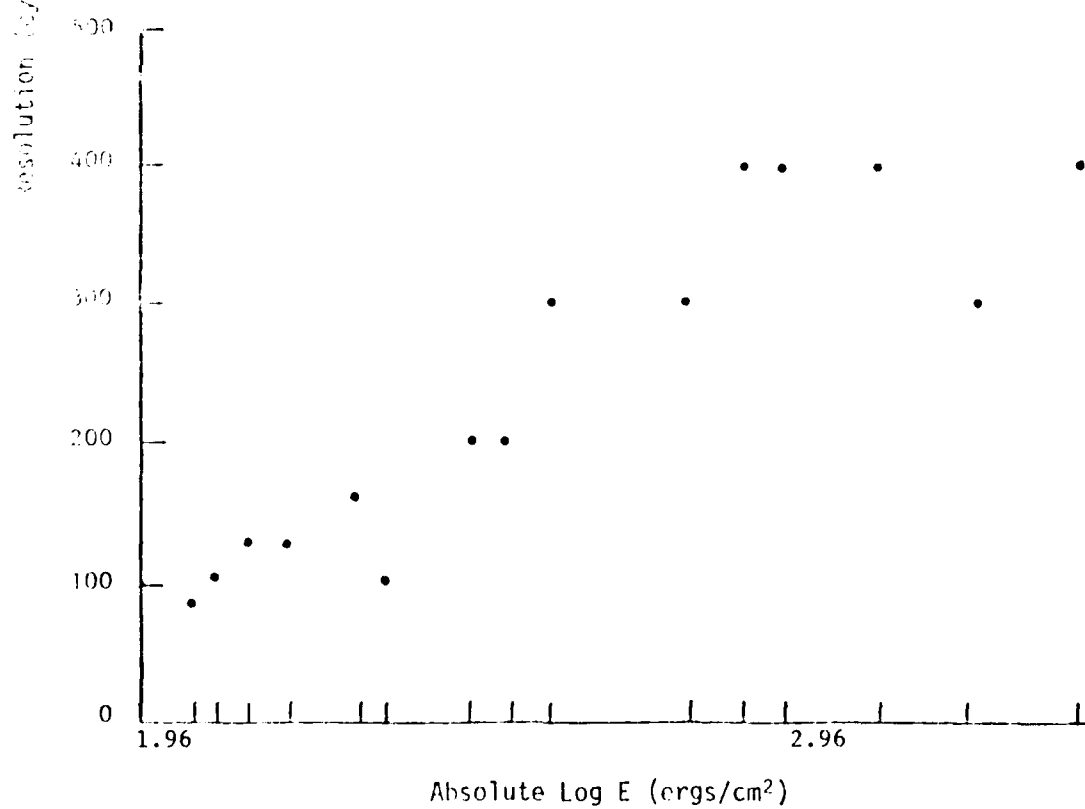
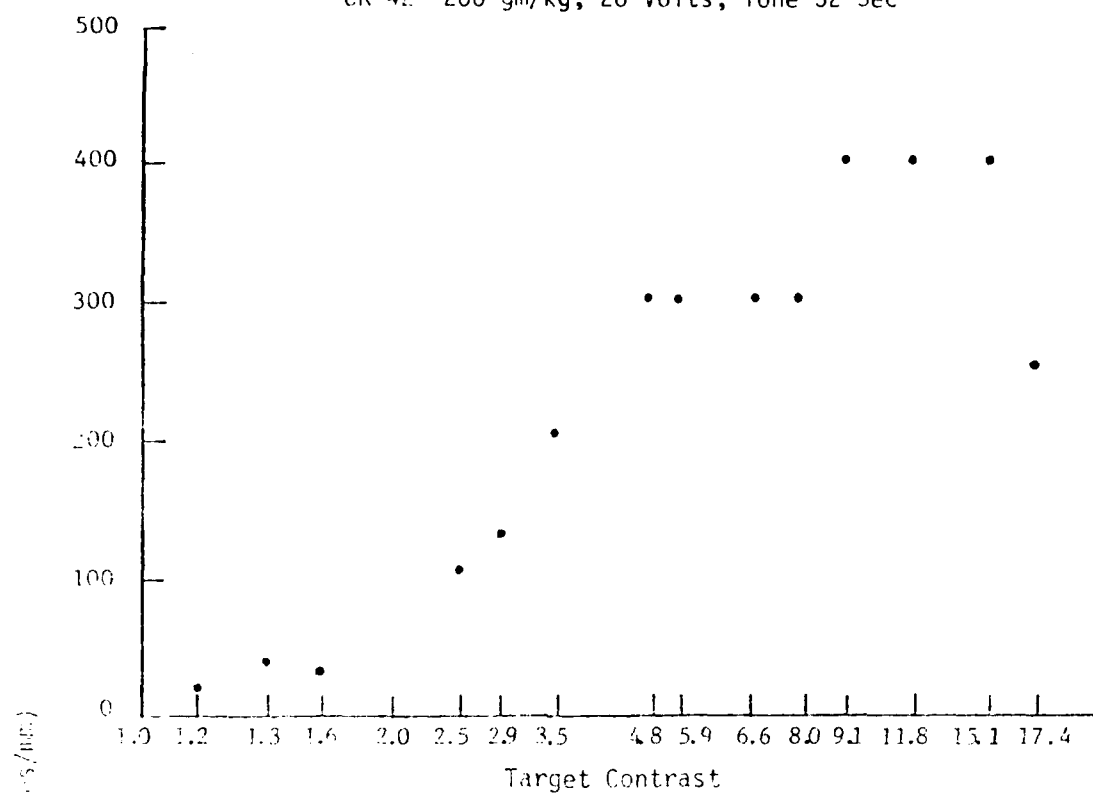


Figure 63

Resolution Response  
CR-42 200 gm/kg, 15 Volts, Tone 32 Sec

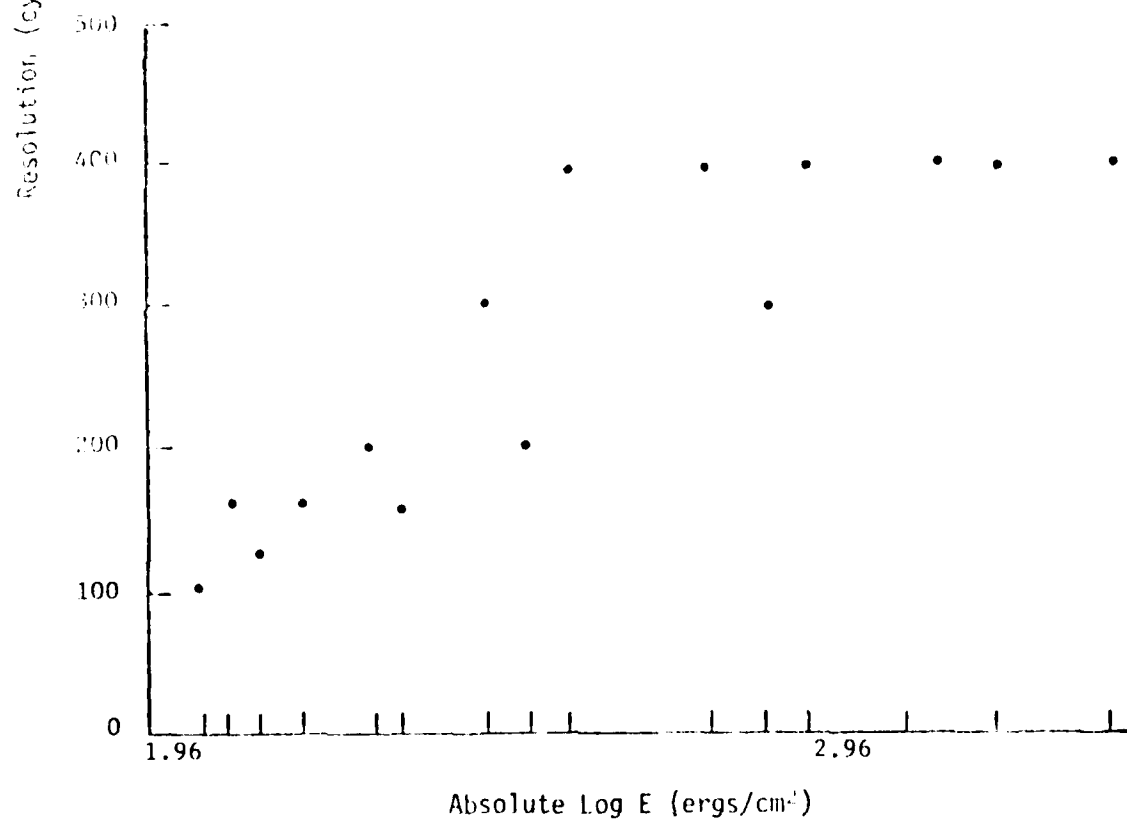
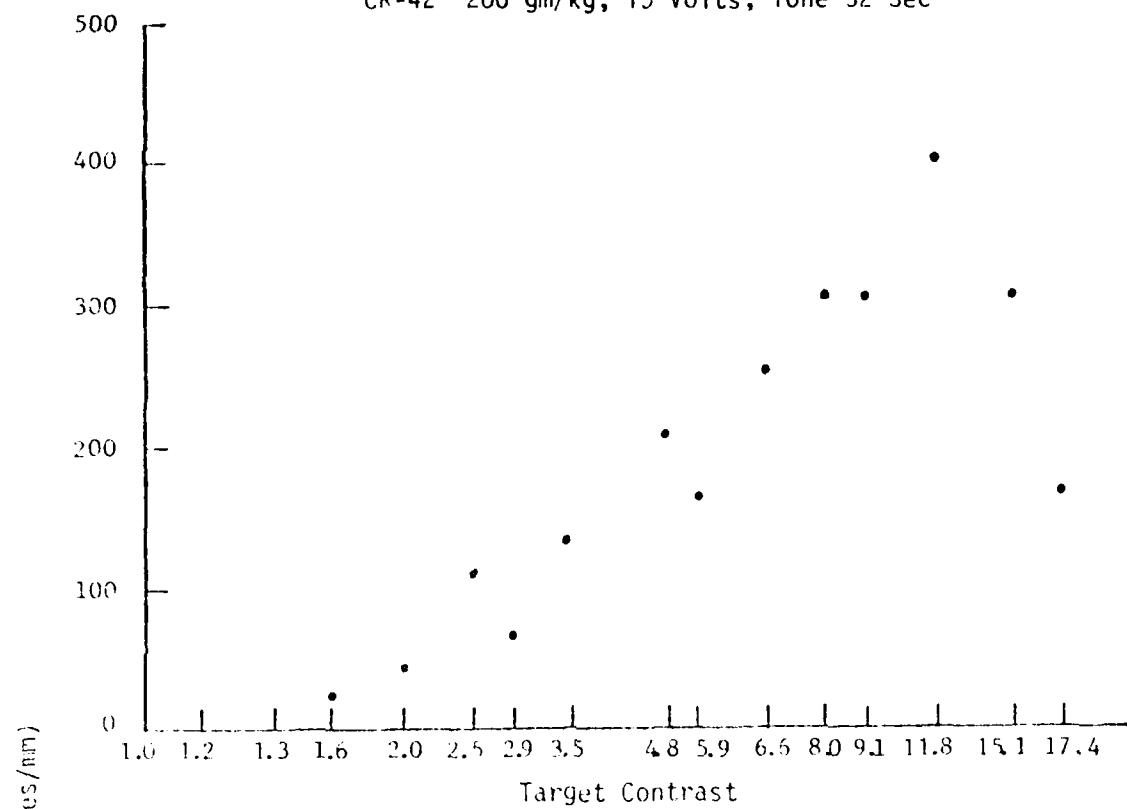


Figure 64

Resolution Response  
CR-42 200 gm/kg, 10 Volts, Tone 32 Sec

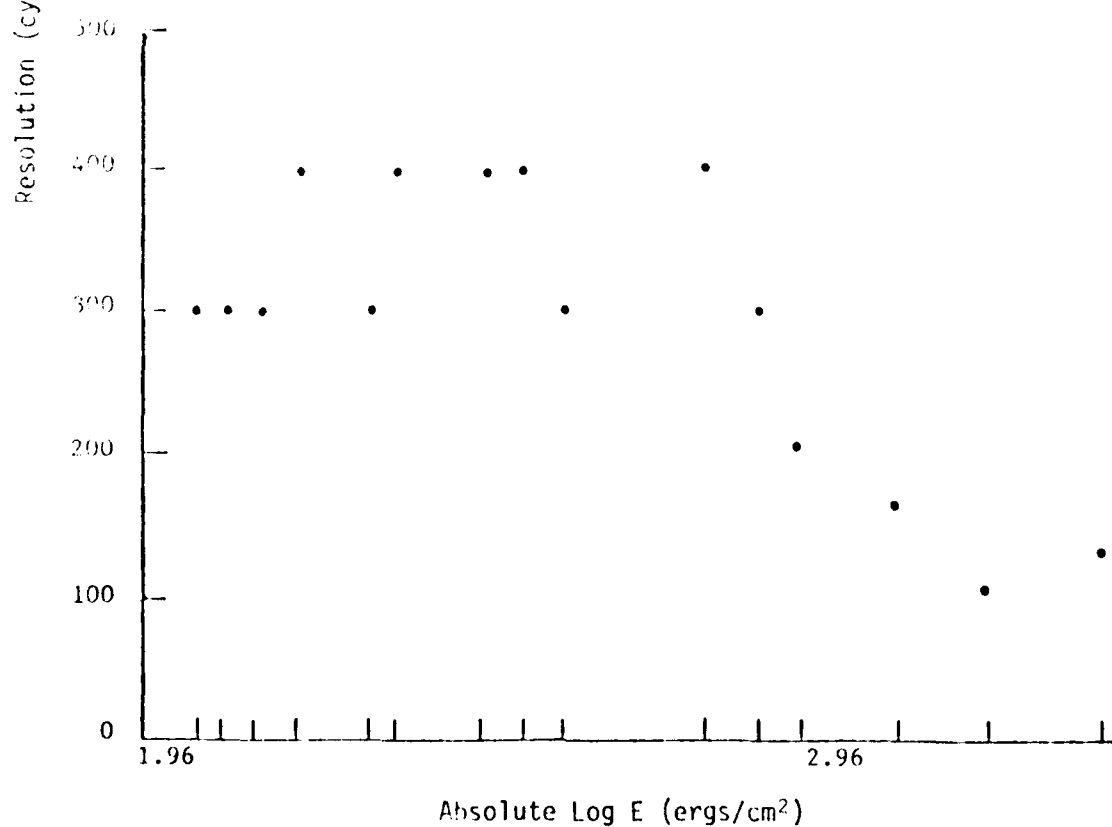
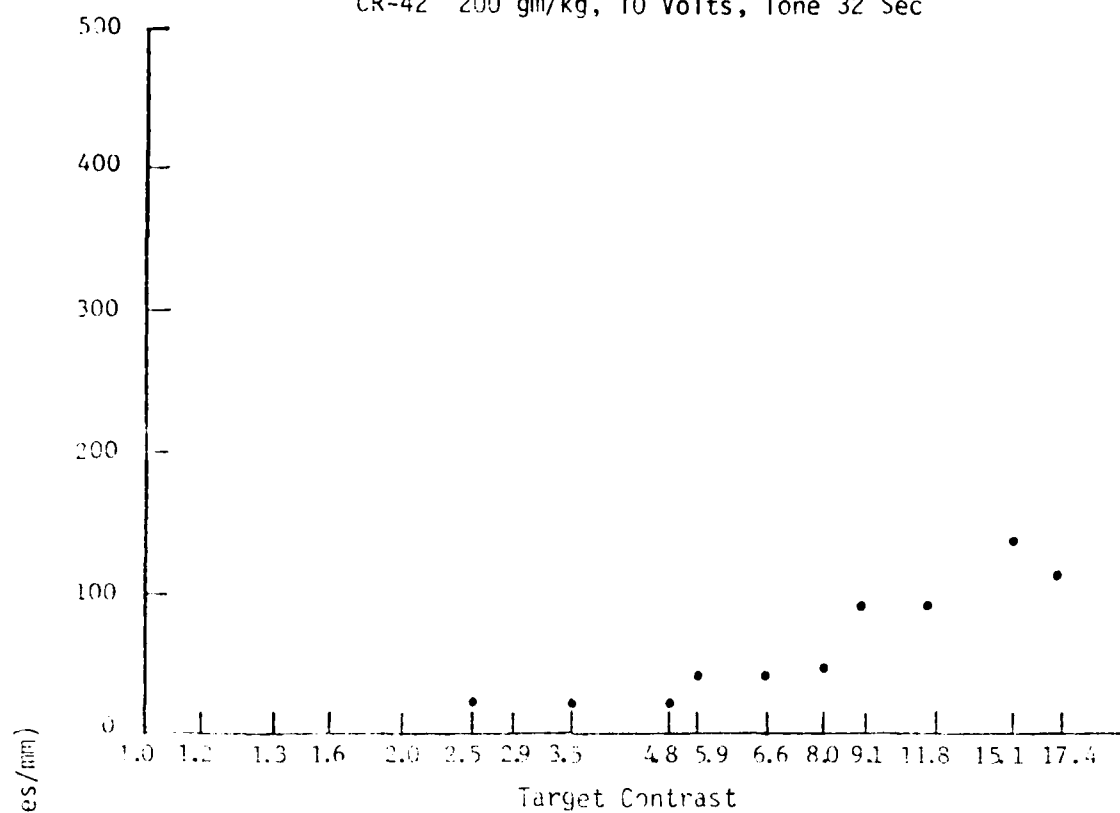


Figure 65

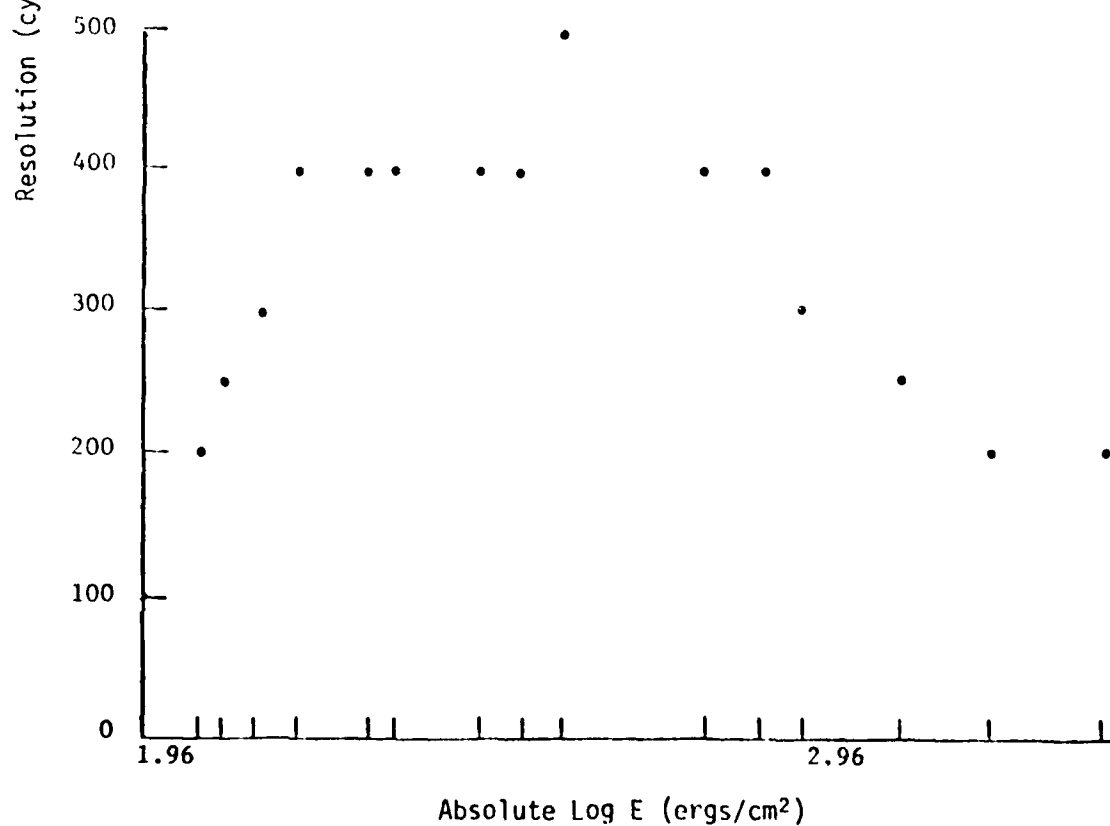
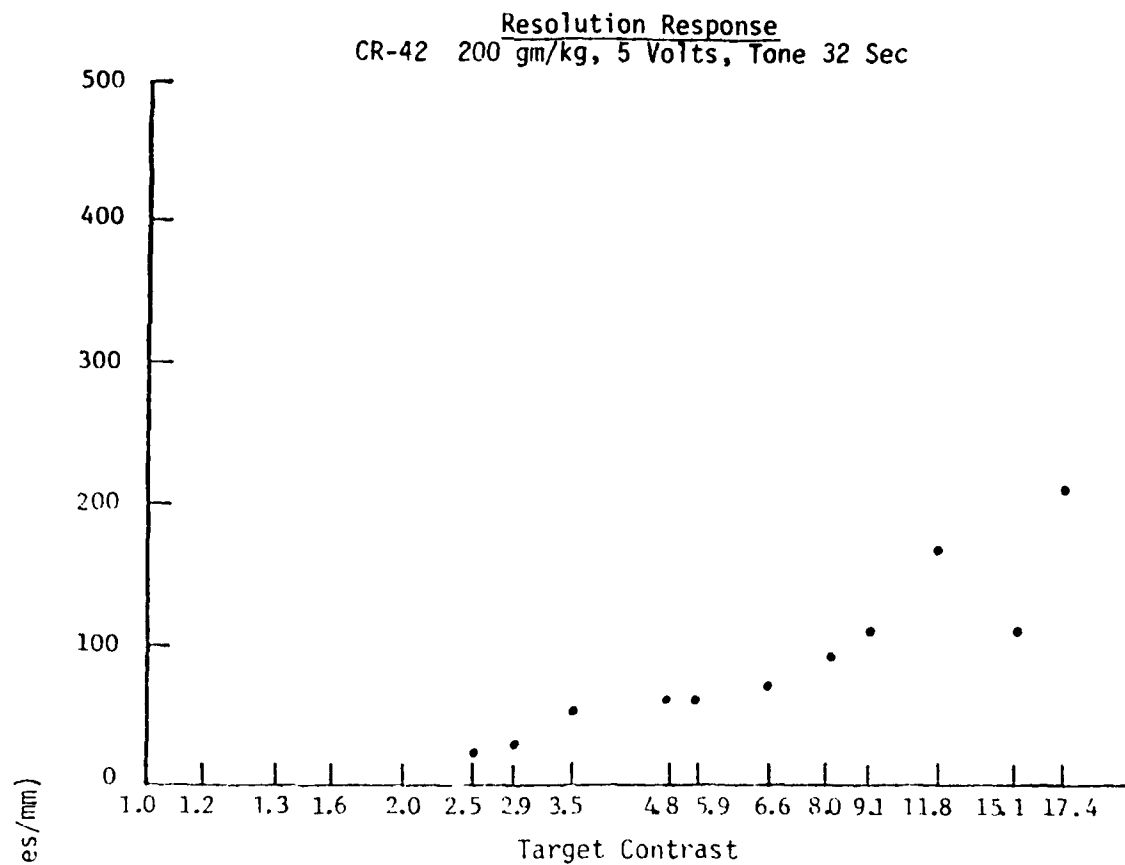


Figure 66

TABLE 5

RESOLUTION VS CONTRAST  
CR-53

Exposure 2.35 Log Ergs/cm <sup>2</sup>						
	Toner Concentration					
	50 gm/kg		100 gm/kg		200 gm/kg	
	Tone		Tone		Tone	
Target Contrast	2 Sec	32 Sec	2 Sec	32 Sec	2 Sec	32 Sec
1.2	250	<10	300	60	500	60
1.3	500	500	300	250	500	250
1.6	400	500	400	400	400	400
2.0	500	500	500	400	400	400
2.5	500	500	500	400	400	400
2.9	500	500	400	400	400	400
3.5	400	500	500	400	300	400
4.8	400	400	300	400	400	500
5.4	400	400	500	400	400	500
6.6	400	500	500	400	400	500
8.0	300	500	500	400	400	400
9.1	250	500	500	400	250	400
11.8	250	400	500	400	400	400
15.1	200	500	500	400	400	500
17.4	250	400	500	500	500	500

Exposure 3.33 Log Ergs/cm <sup>2</sup>						
Target Contrast	2 Sec	32 Sec	2 Sec	32 Sec	2 Sec	32 Sec
1.2	25	<10	<10	<10	<10	<10
1.3	<10	<10	<10	<10	<10	<10
1.6	30	30	30	30	<10	<10
2.0	250	40	80	40	40	30
2.5	200	250	200	50	50	50
2.9	250	250	300	250	125	100
3.5	150	400	400	250	400	125
4.8	300	400	400	300	400	250
5.4	250	300	400	400	300	250
6.6	300	400	400	400	300	300
8.0	300	400	400	400	400	400
9.1	400	300	400	400	400	400
11.8	400	400	400	250	400	400
15.1	250	400	400	500	300	400
17.4	400	400	400	500	300	400

TABLE 6

RESOLUTION VS EXPOSURE  
CR-53 - Target Contrast 17.4/1

	Tone 2 Sec			Tone 32 Sec						Tone 60 Sec		
	Expose No Delay Tone			Expose Delay 60 Sec Tone			Expose No Delay Tone			Expose Delay 60 Sec Tone		
	Concentration gm/kg			Concentration gm/kg			Concentration gm/kg			Concentration gm/kg		
	50	100	200	50	100	200	50	100	200	50	100	200
1.07	300	200	250	160	125	50	300	160	160	200	125	160
1.09	300	250	250	200		60	300	160	200	200	160	160
1.15	300	300	300	200	160	60	300	200	200	200	200	160
1.21	300	300	300	160	200	60	300	200	200	250	200	200
1.31	300	400	400		200	80	400	250	200	250	200	200
1.37	400	400	500	200	250	100	400	250	250	300	200	200
1.48	400	400	500	250	250	125	500	300	300	250	250	250
1.53	400	400	400	300	300	125	400	200	300	250	250	250
1.59	400	500	500	250	300	200	400	400	400	200	300	300
1.79	400	500	500	200	400	200	400	400	400	250	400	400
1.87	400	400	500	400	400	200	500	400	400	250	400	400
1.93	400	500	500	400	400	200	500	500	400	250	500	400
2.04	400	500	500	400	500	250	500	500	500	300	500	500
2.05	400	500	500	400	400	400	400	500	500	400	300	300
2.07	300	500	500	400	400	500	500	500	500	400	400	400
2.14		400	500	300	500	500	400	500	500	400	400	500
2.18		500	500	400	500	500	500	500	500	400	500	500
2.28		500	500	200	500	500	500	500	500	400	500	400
2.32		400	500	250	400	500	400	500	500	400	500	400
2.49		400	500	200	500	400	500	500	500	400	500	500
2.50		500	500	160	500	500	400	500	500	500	500	500
2.56		300	500	160	500	500	400	500	500	500	500	500
2.76		250	400	160	400	500	500	500	400	400	500	400
2.84		500	500	200	500	500	500	500	500	500	500	500
2.90		500	500	160	500	500	500	500	400	400	500	400
3.04		500	500	160	500	500	500	500	500	500	500	500
3.17		500	500	300	500	500	500	500	500	500	500	500
3.33		400	400	400	500	500	400	500	500	400	500	400

**TABLE 7**

**RESOLUTION VS CONTRAST**  
**CR-42**

Exposure 2.35 Log Ergs/cm <sup>2</sup>												
Target Contrast	50 gm/kg				Toner Concentration 100 gm/kg				200 gm/kg			
	5V	10V	15V	20V	5V	10V	15V	20V	5V	10V	15V	20V
1.2				250				200				125
1.3				400				400				160
1.6				400				400				400
2.0				500				400				400
2.5				400				400				400
2.9				500				400				400
3.5				400				400				300
4.8				400				500				400
5.4				400				400				400
6.6				400				500				400
8.0				400				500				400
9.1				300				400				250
11.8				300				400				250
15.1				300				500				400
17.4				300				400				400

Exposure 3.33 Log Ergs/cm <sup>2</sup>												
Target Contrast	50 gm/kg				Toner Concentration 100 gm/kg				200 gm/kg			
	5V	10V	15V	20V	5V	10V	15V	20V	5V	10V	15V	20V
1.2	<10	<10	<10	20	<10	<10	<10	16	<10	<10	<10	<10
1.3	<10	<10	<10	60	<10	<10	25	20	<10	<10	<10	<10
1.6	<10	<10	<10	30	<10	<10	<10	60	<10	<10	31	<10
2.0	<10	25	30	250	<10	<10	25	100	<10	<10	40	<10
2.5	30	30	60	200	30	25	100	200	30	30	100	<10
2.9	40	25	160	250	50	30	125	200	40	<10	60	40
3.5	60	80	200	125	60	40	250	125	50	30	125	60
4.8	80	125	200	300	100	100	200	400	60	30	200	100
5.4	125	160	300	250	100	100	300	300	60	50	160	200
6.6	125	200	400	300	160	100	300	300	80	50	250	250
8.0	125	200	400	300	200	125	250	300	100	60	300	300
9.1	250	250	400	400	250	125	400	400	125	100	300	300
11.8	400	300	400	400	250	200	400	400	160	100	400	400
15.1	300	300	200	250	300	125	400	400	125	160	300	400
17.4	300	300	400	400	250	200	400	400	200	125	160	400

TABLE 8

RESOLUTION VS EXPOSURE  
CR-42 - Target Contrast 17.4/1

	Surface Voltage											
	5V			10V			15V			20V		
	Concentration gm/kg			Concentration gm/kg			Concentration gm/kg			Concentration gm/kg		
	50	100	200	50	100	200	50	100	200	50	100	200
1.07										63	50	40
1.09										63	40	60
1.15										80	60	60
1.21										125	80	60
1.31										160	125	80
1.37										200	125	100
1.48										250	160	125
1.53										160	200	125
1.59										200	250	200
1.79										200	300	200
1.87										250	250	200
1.93										250	300	200
2.04										250	300	250
2.05	300	300	200	300	250	300	200	200	100	250	200	160
2.07	400	400	250	300	300	300	250	200	160	200	200	300
2.14	400	300	300	300	300	300	300	200	125	250	250	250
2.18	500	400	400	500	300	400	300	250	160	250	250	250
2.28	500	500	400	400	400	300	300	300	200	300	300	300
2.32	500	500	400	400	500	400	300	300	160	300	300	300
2.44	500	500	400	500	400	400	300	400	300	300	400	300
2.50	500	400	400	400	400	400	300	400	200	300	300	300
2.56	500	500	500	400	400	300	500	400	400	300	400	300
2.76	500	400	400	400	400	400	500	400	400	400	300	400
2.84	400	400	400	400	400	300	500	400	300	400	400	300
2.90	300	400	300	400	400	200	500	500	400	500	400	400
3.04	400	300	250	400	250	160	500	400	400	400	500	400
3.17	300	400	200	400	200	100	400	400	400	400	400	300
3.33	300	300	200	250	200	125	400	400	400	400	400	400

### 3.8 Resolution as a Function of Delay Time

The manual precision imaging system was used for these experiments. The multi-element evaporated target was used in the contact mode. It was planned to employ delays from one second to 60 seconds between exposure and toning. Initial testing showed little change in resolution as a function of delay time. Therefore the maximum delay was used throughout. Toners CR-42 and CR-53 were used at 50, 100, and 200 gm/kg. Thirty-two seconds toning time was used with both toners. Additionally, the CR-53 was used with a toning time of 60 seconds. The results of this experiment are shown in figures 67 through 86 and Table 6.

### 3.9 Granularity CR-42 and CR-53

#### 3.9.1 Procedure

The manual precision imaging system was used to prepare samples for determination of granularity. Samples were charged and dark decayed to provide a density of approximately 1.0 above base plus fog. Microdensitometer traces were made using a Joyce Loebel instrument Mark IIIC, Serial No. 584. A 10X objective and condenser were employed, and an effective circular aperture of 24  $\mu\text{m}$  was used. Calibrated diffuse density was obtained by scanning a step wedge for each toner compared to diffuse density measured with a Macbeth TD-518 densitometer. Over the small excursions observed, departures due to specularities as well as linearity were within measurement error.

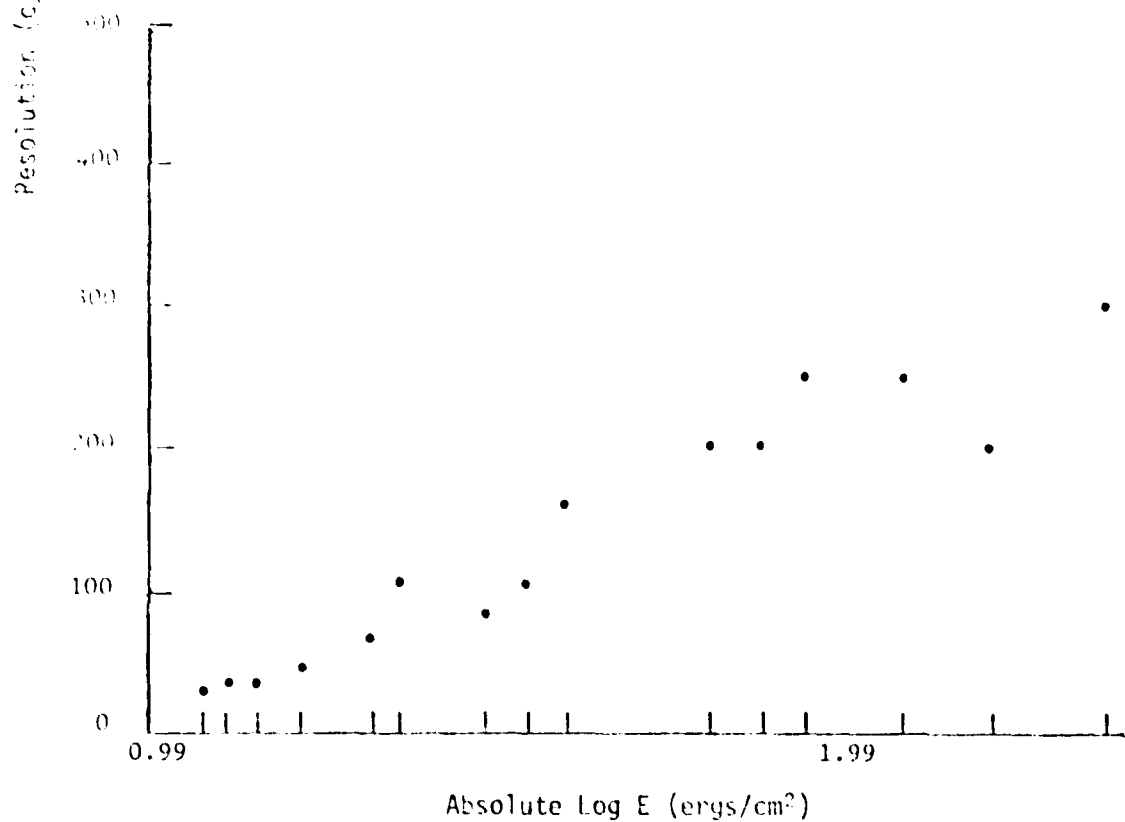
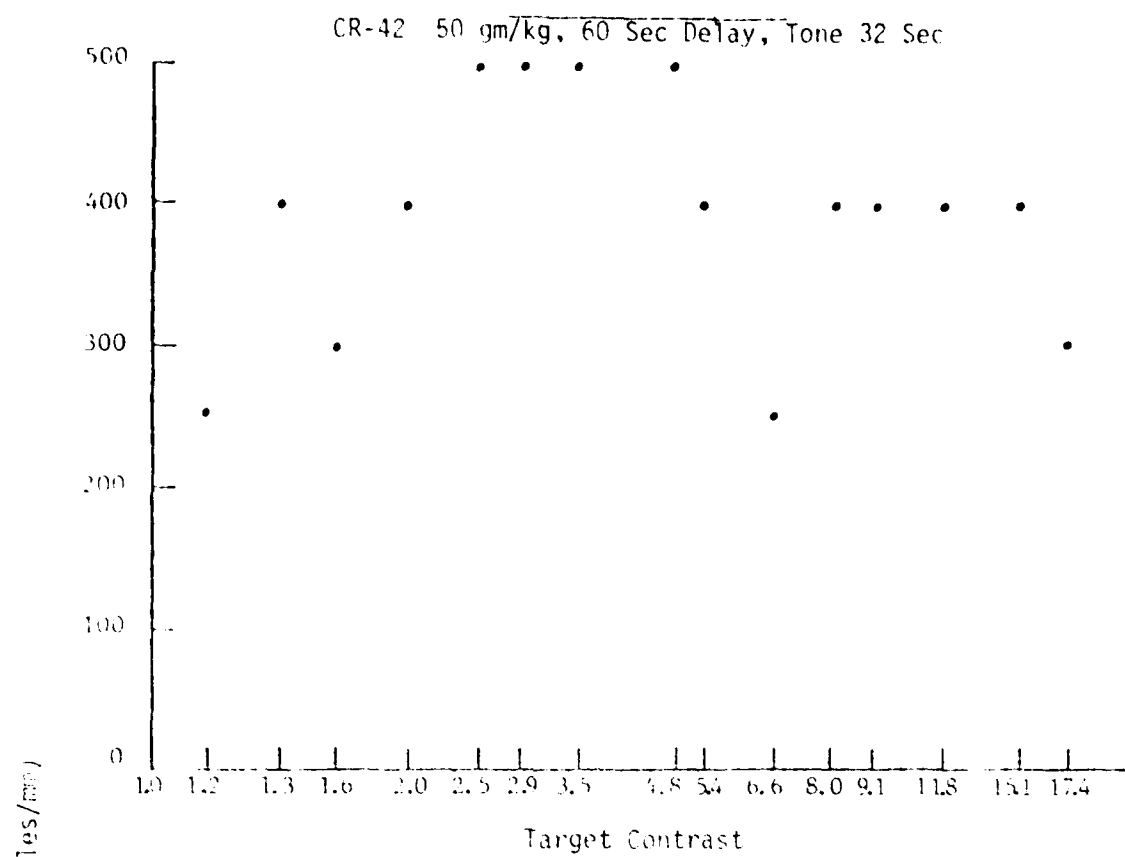


Figure 67

CR-42 50 gm/kg, 60 Sec Delay, Tone 32 Sec

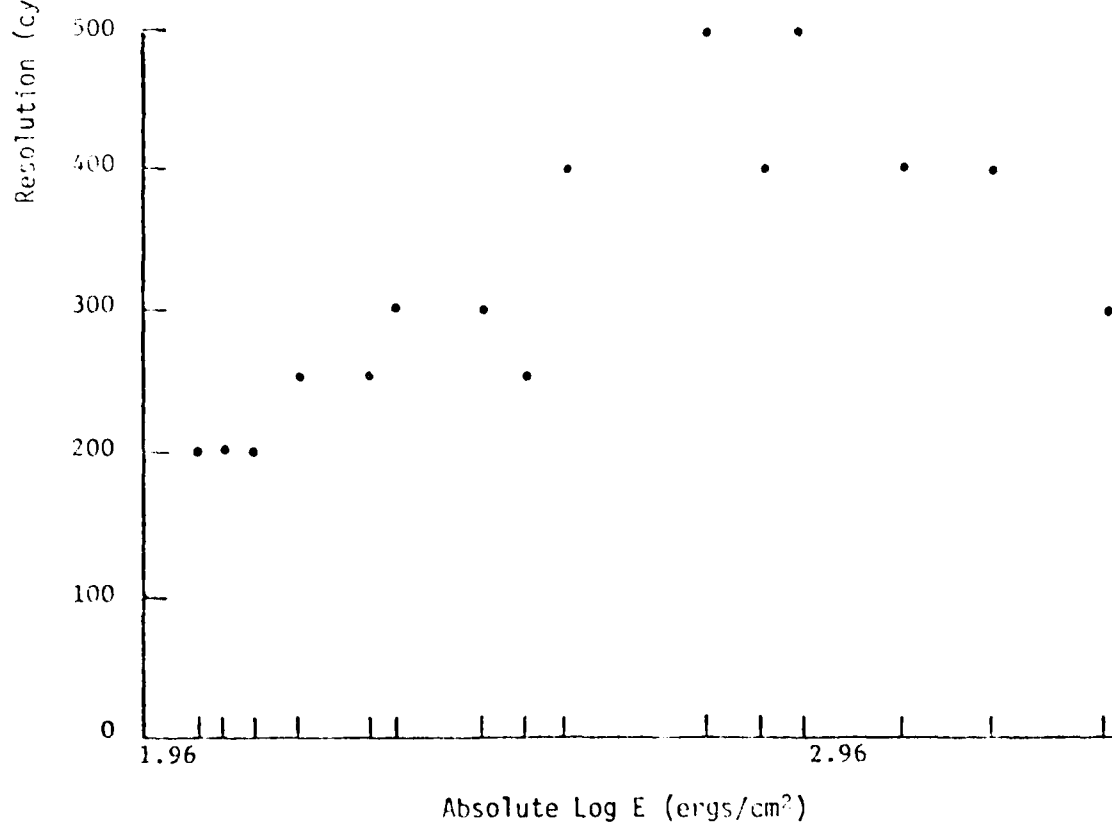
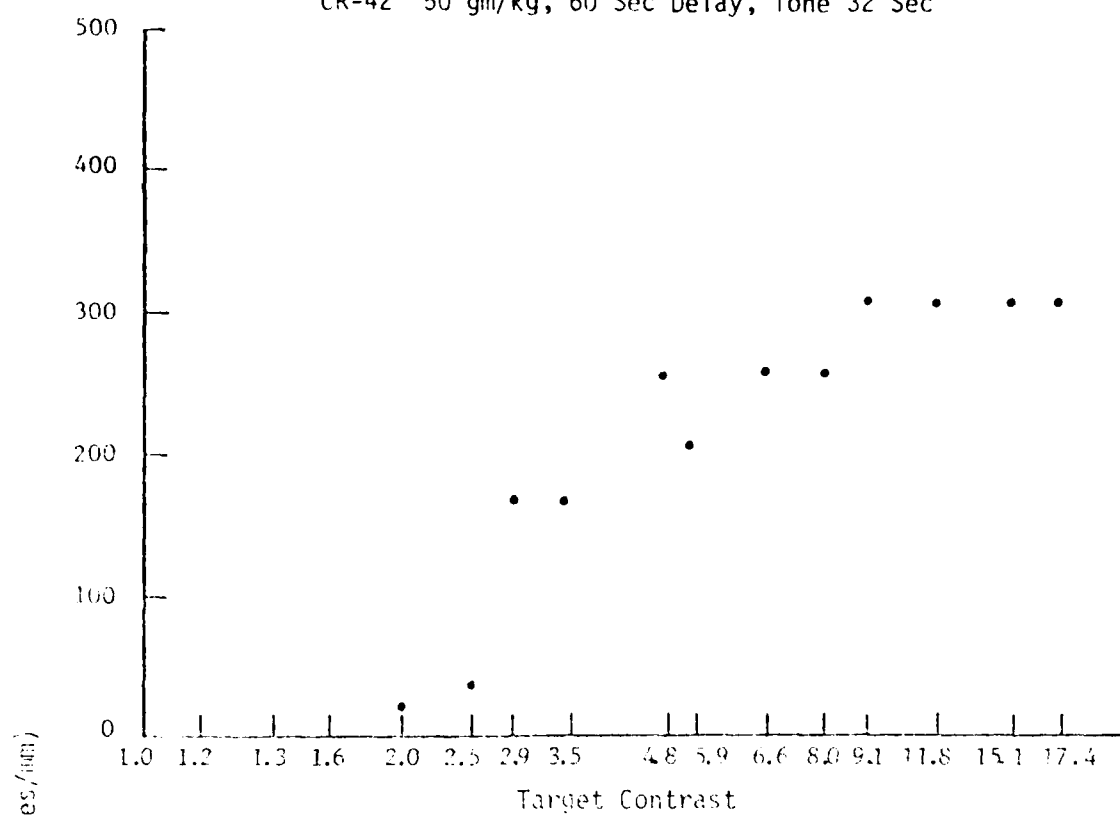


Figure 68

CR-42 100 gm/kg, 60 Sec Delay, Tone 32 Sec

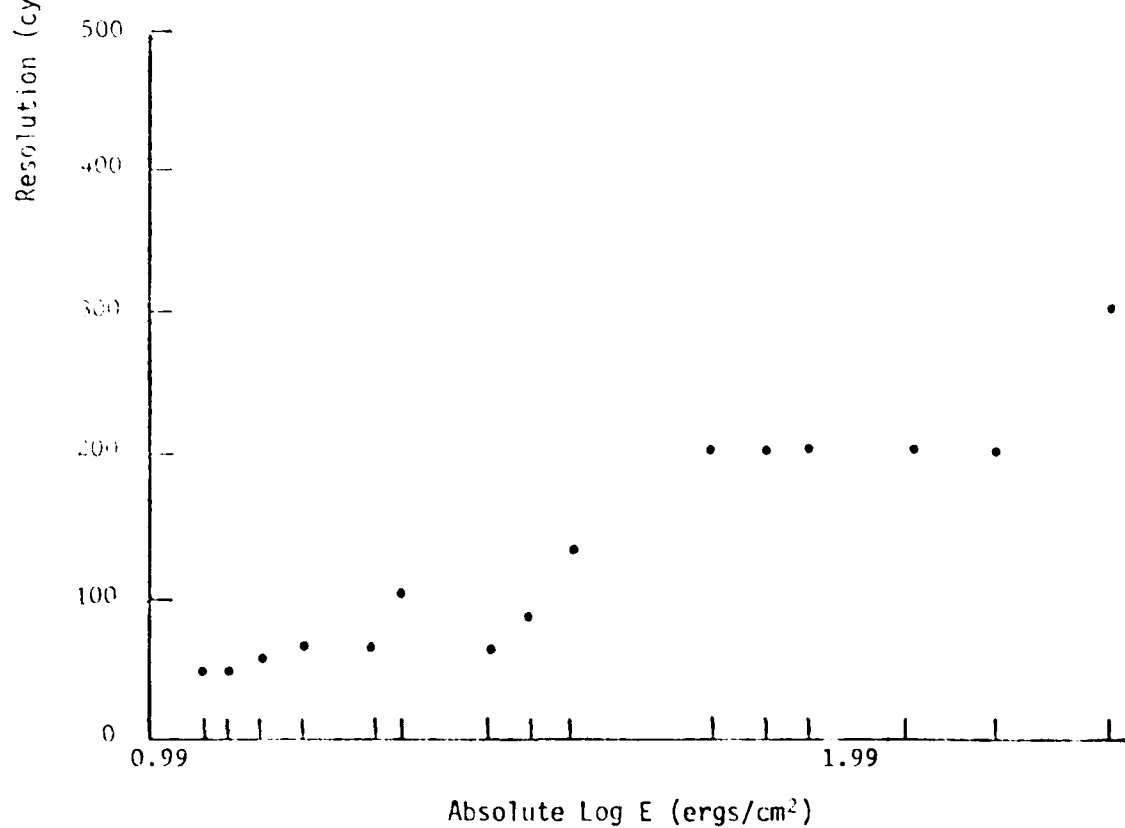
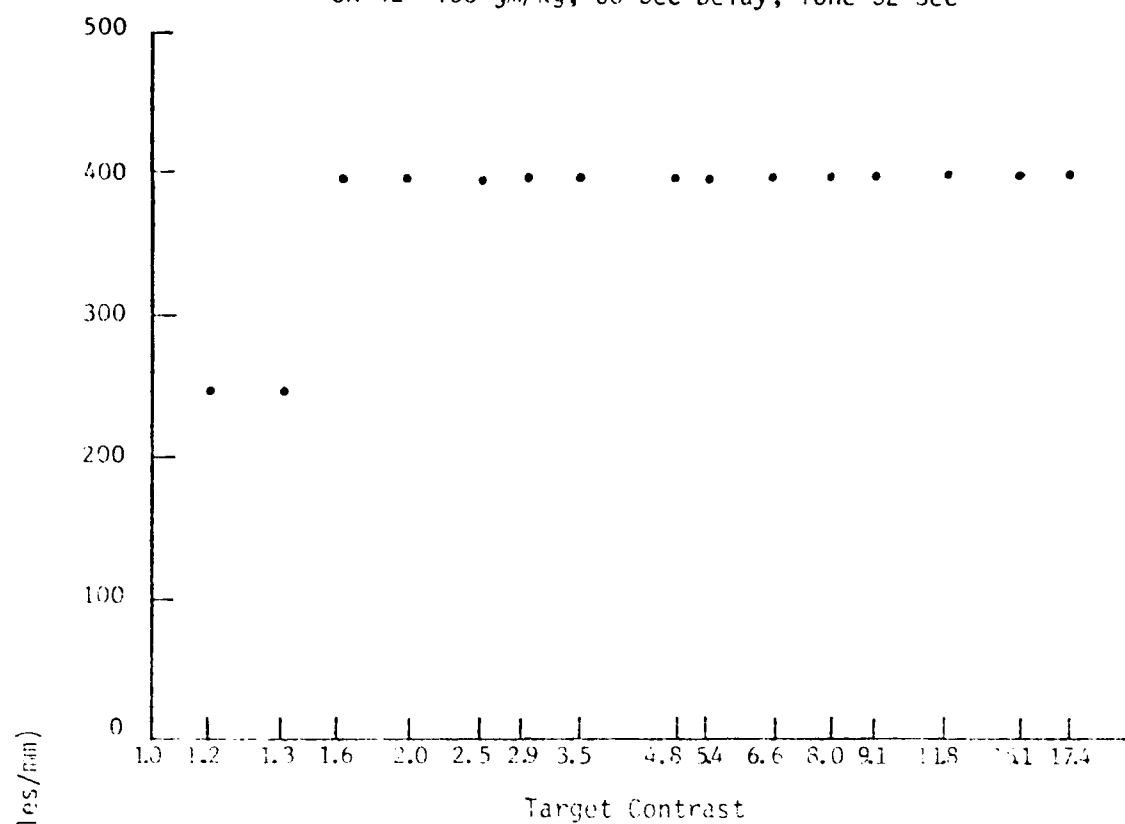


Figure 69

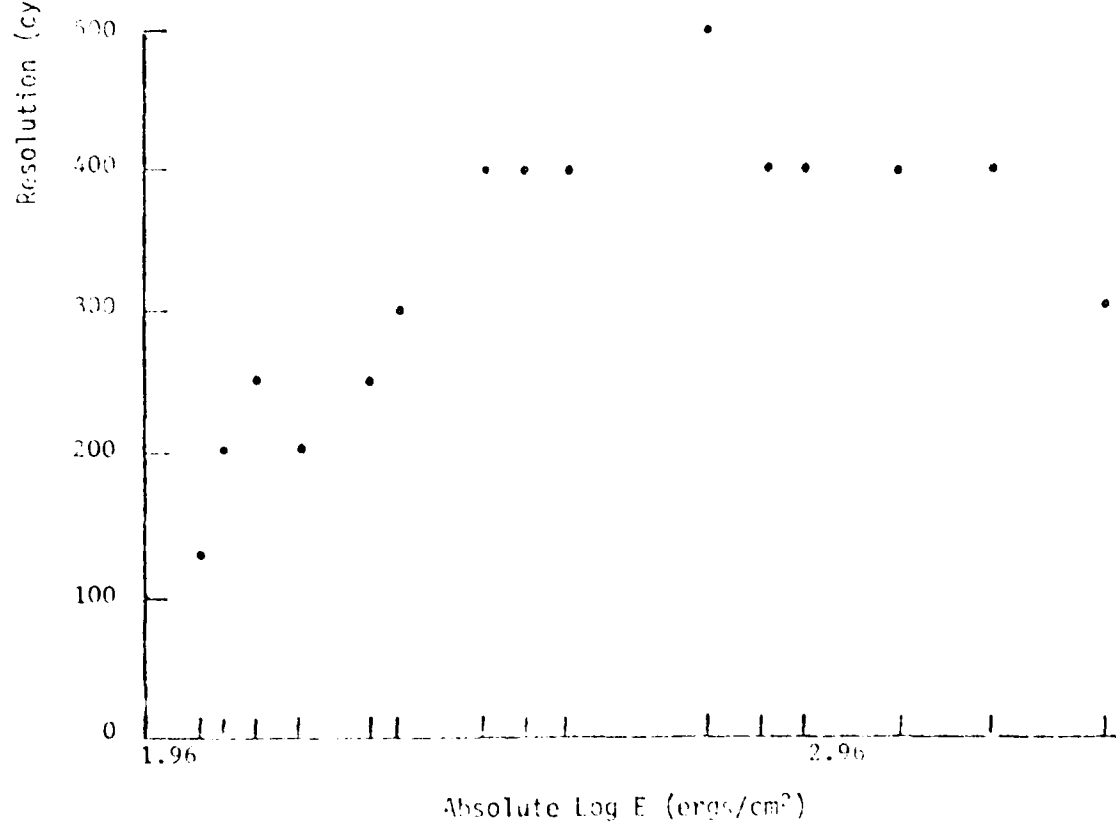
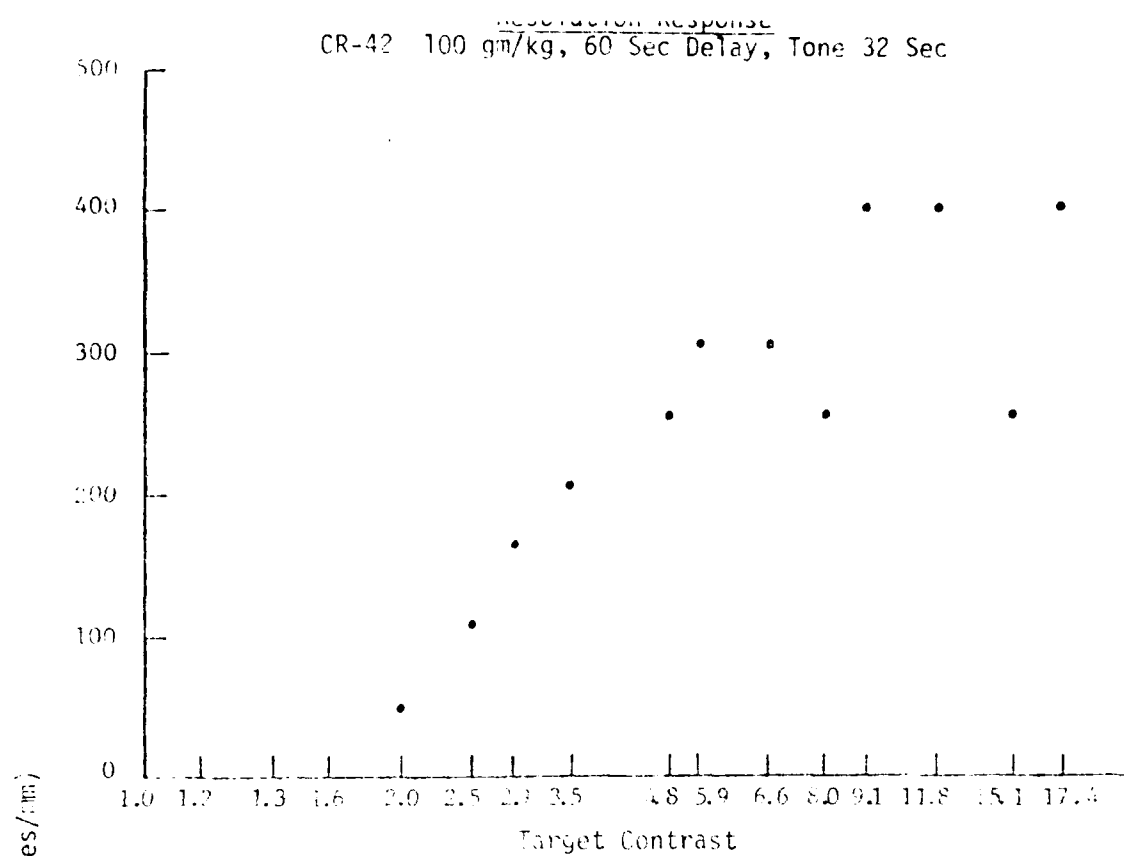


Figure 70

AD-A091 692

COULTER SYSTEMS CORP BEDFORD MA GOVERNMENT SYSTEMS DIV  
TECHNICAL DATA ON KC-FILM: TONERS AND PROCESSES. (U)

F/G 14/5

APR 80 K A LINDBLOM, M WRIGHT

DAAK70-79-C-0116

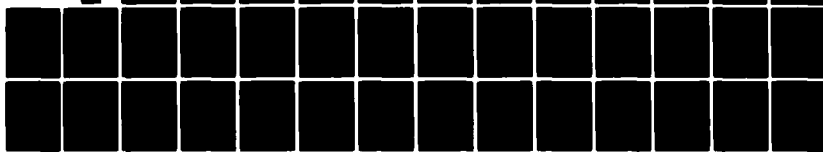
UNCLASSIFIED

ETL-0224

NL

2 of 2

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ACQUISITION



END

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12-80

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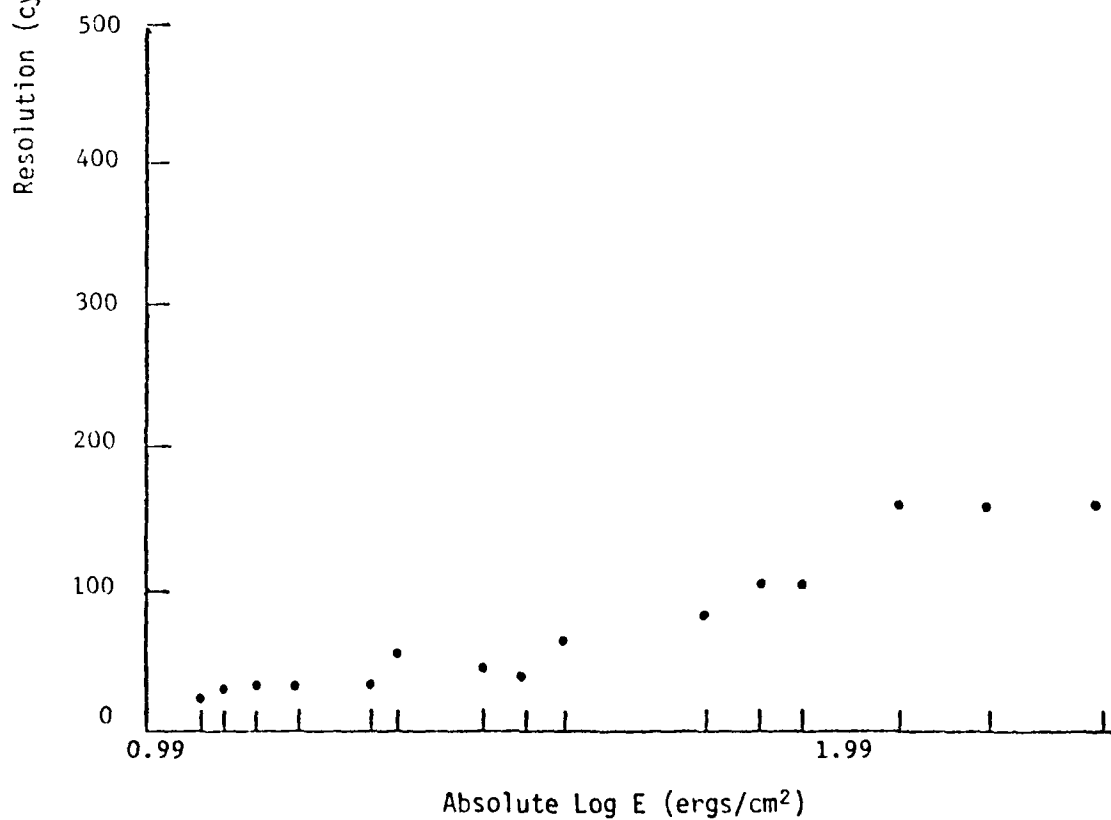
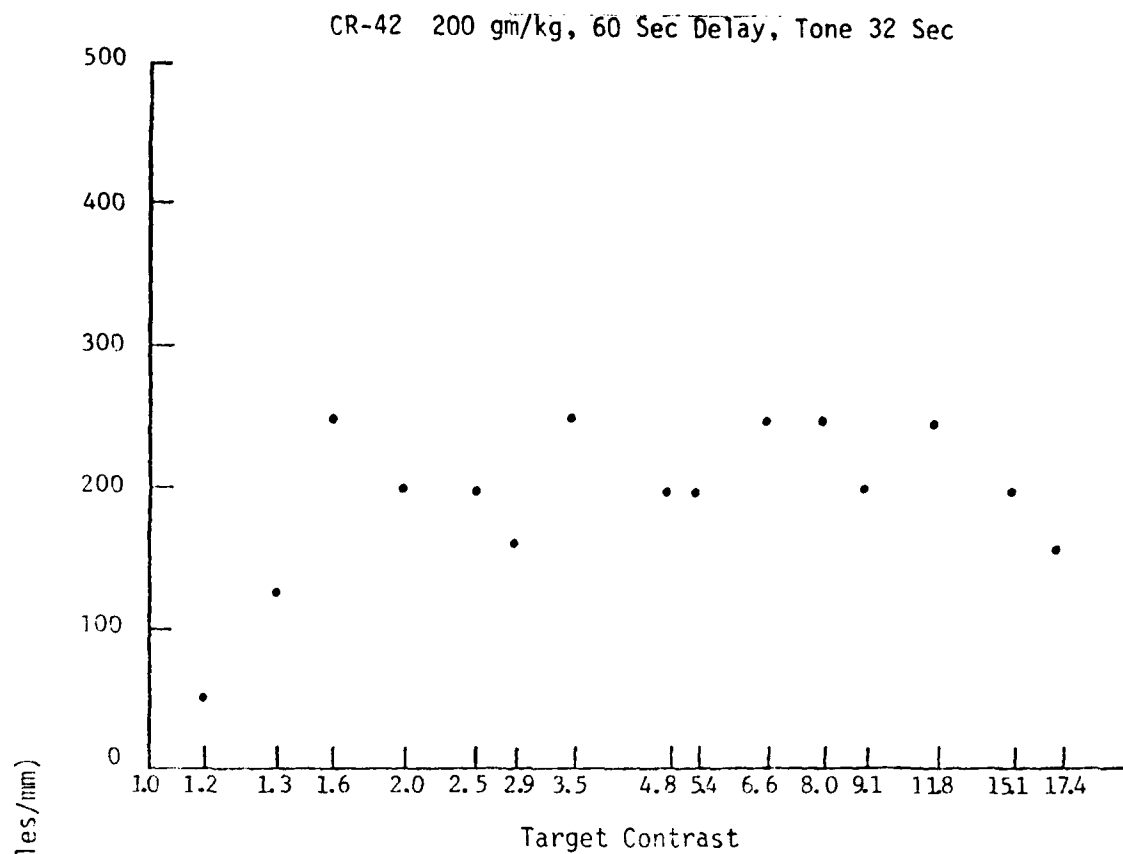


Figure 71

CR-42 200 gm/kg, 60 Sec Delay, Tone 32 Sec

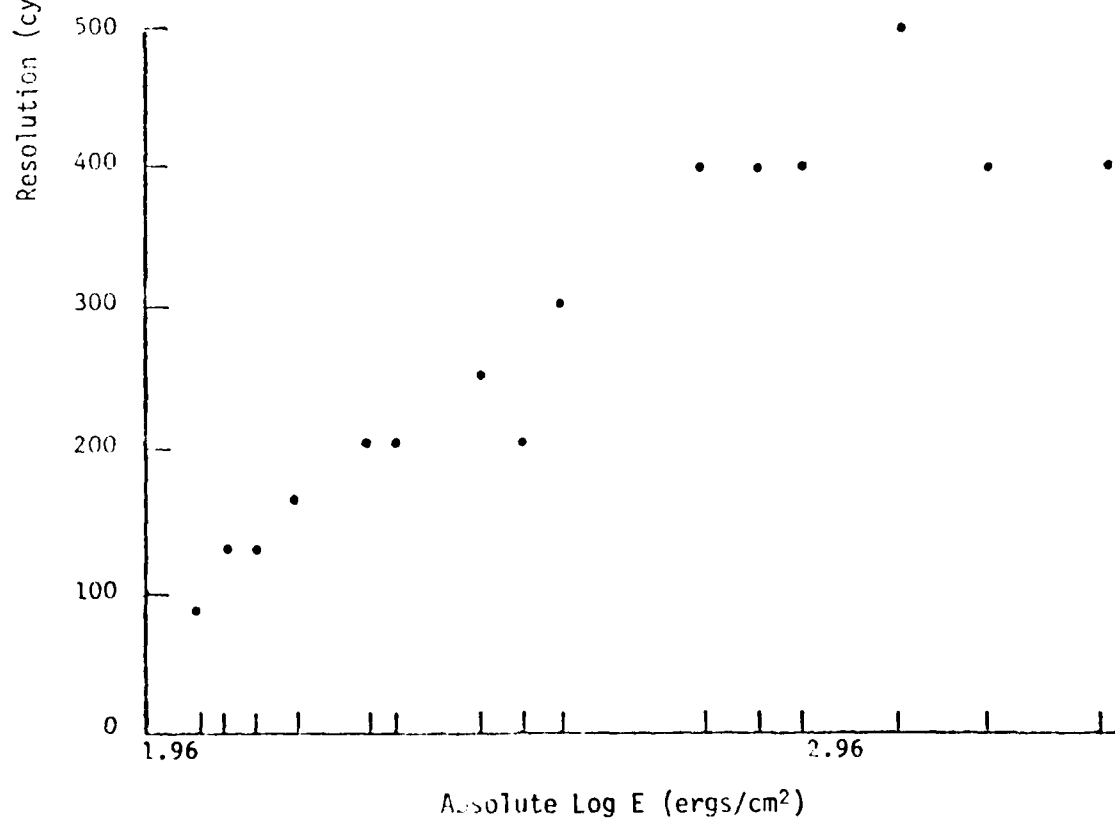
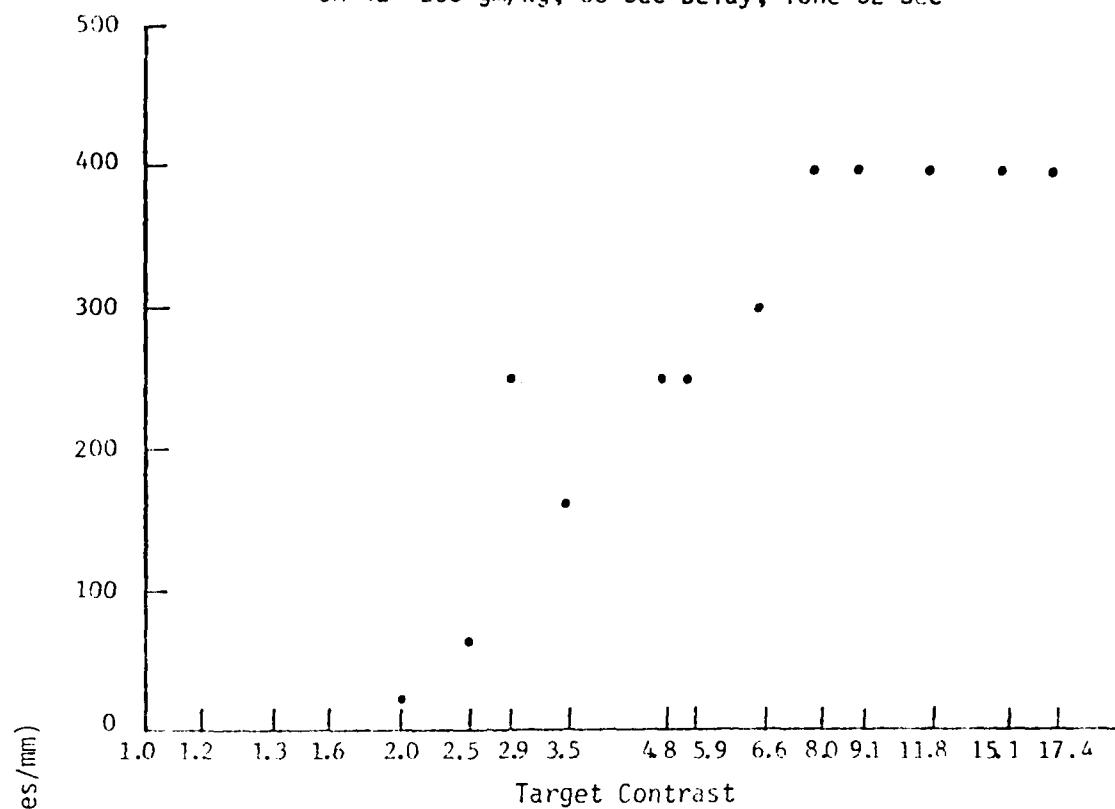


Figure 72

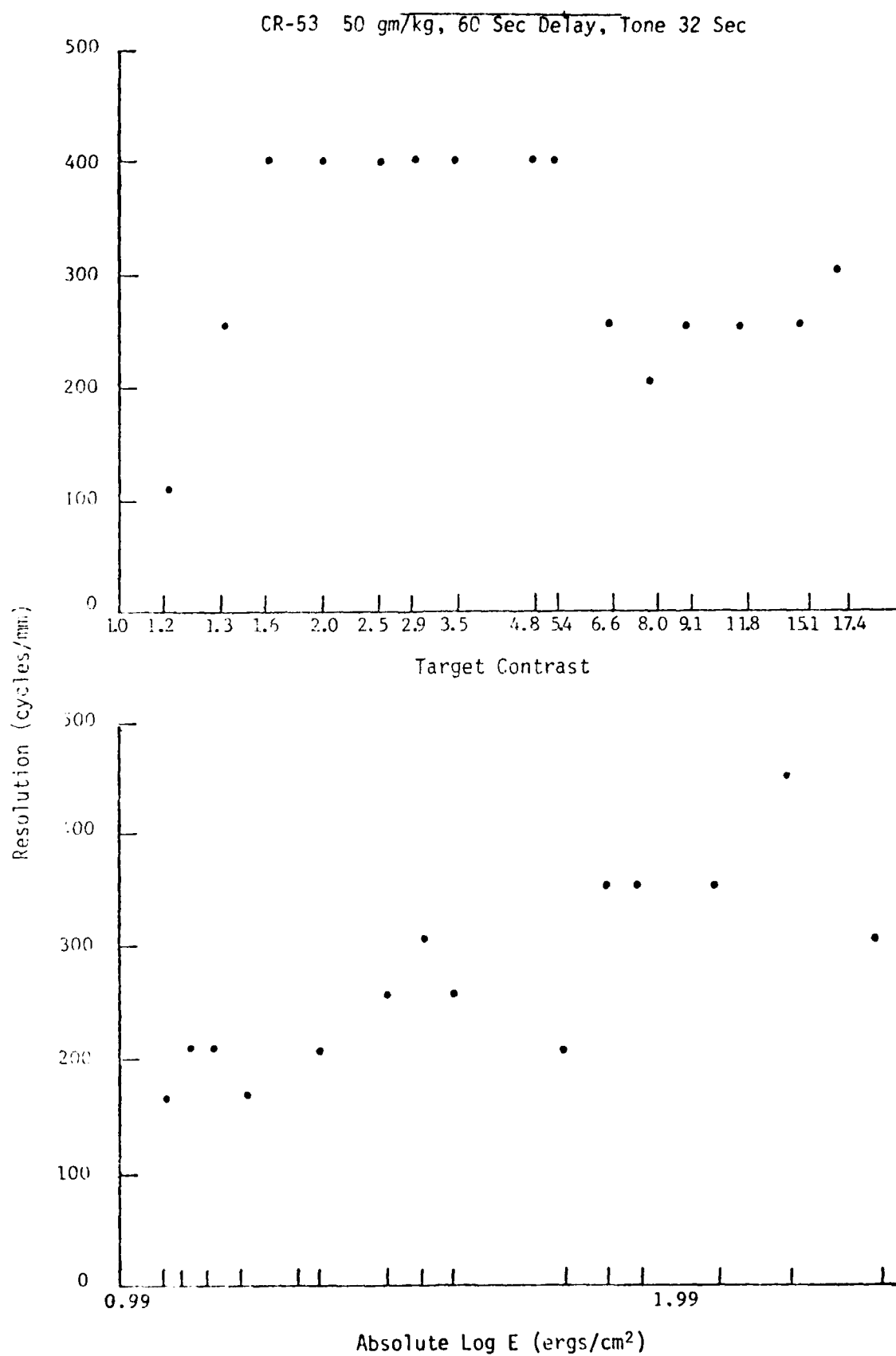


Figure 73

CR-53 50 gm/kg, 60 Sec Delay, Tone 32 Sec

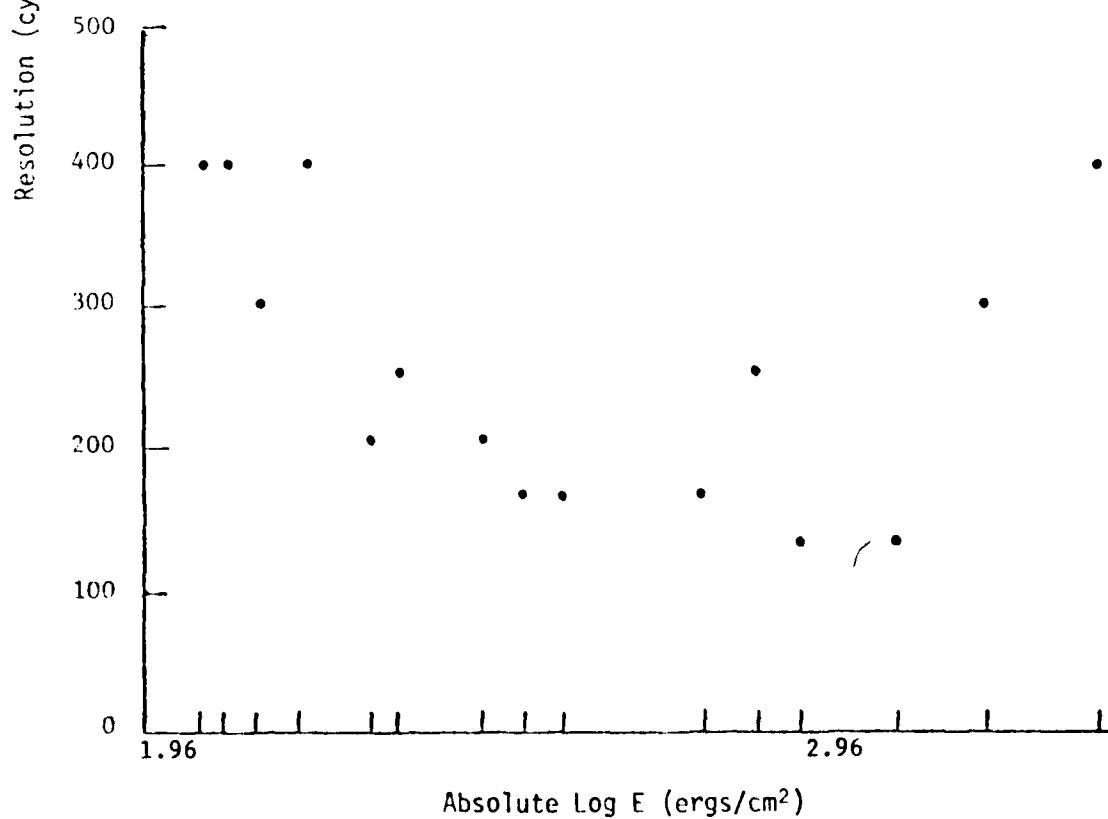
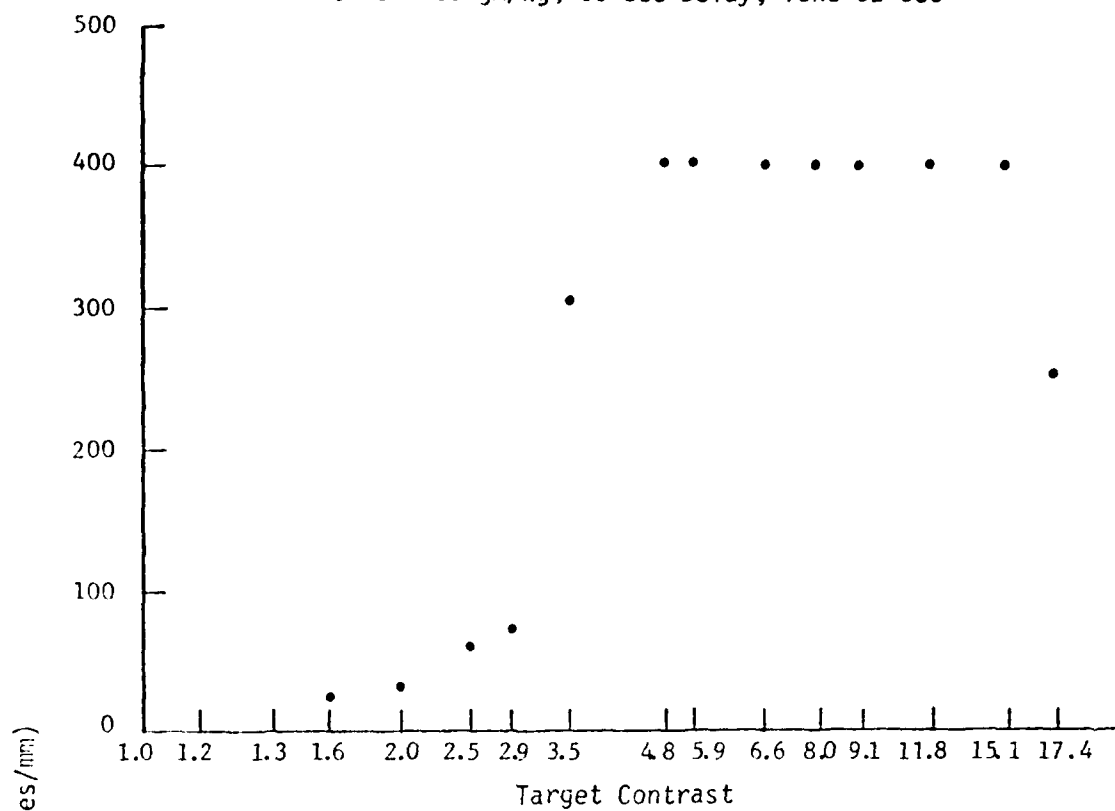


Figure 74

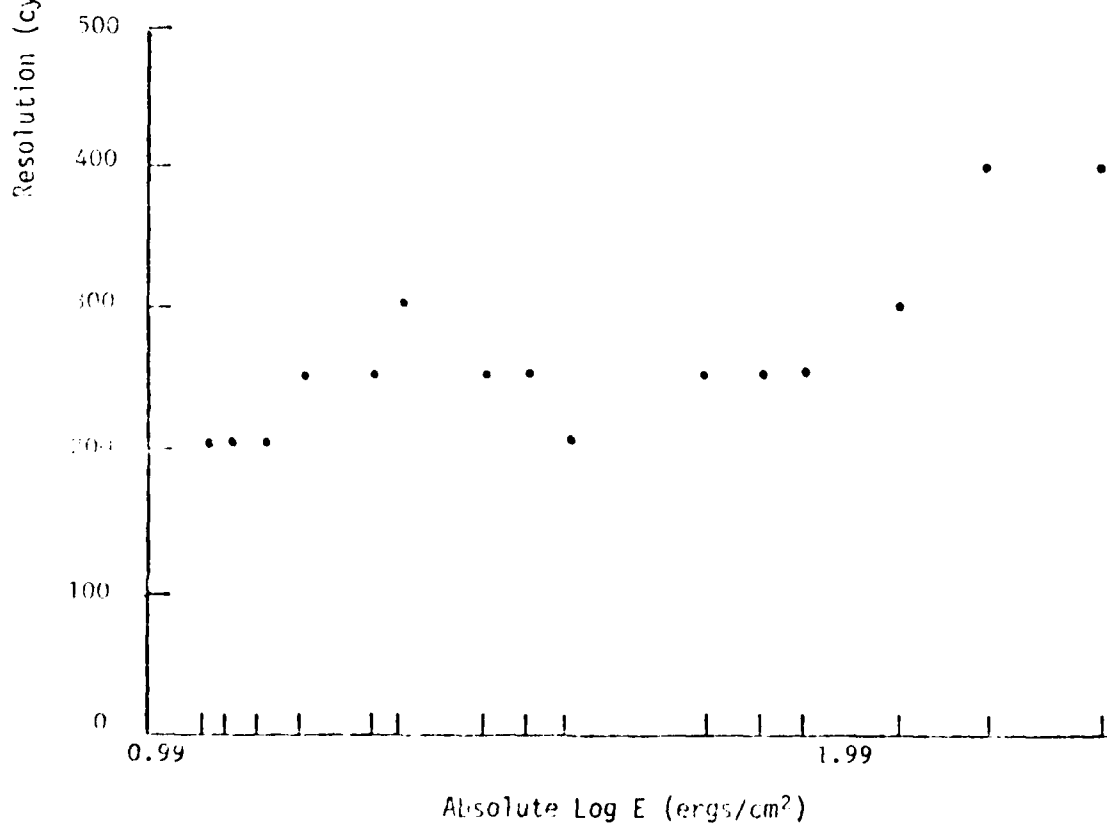
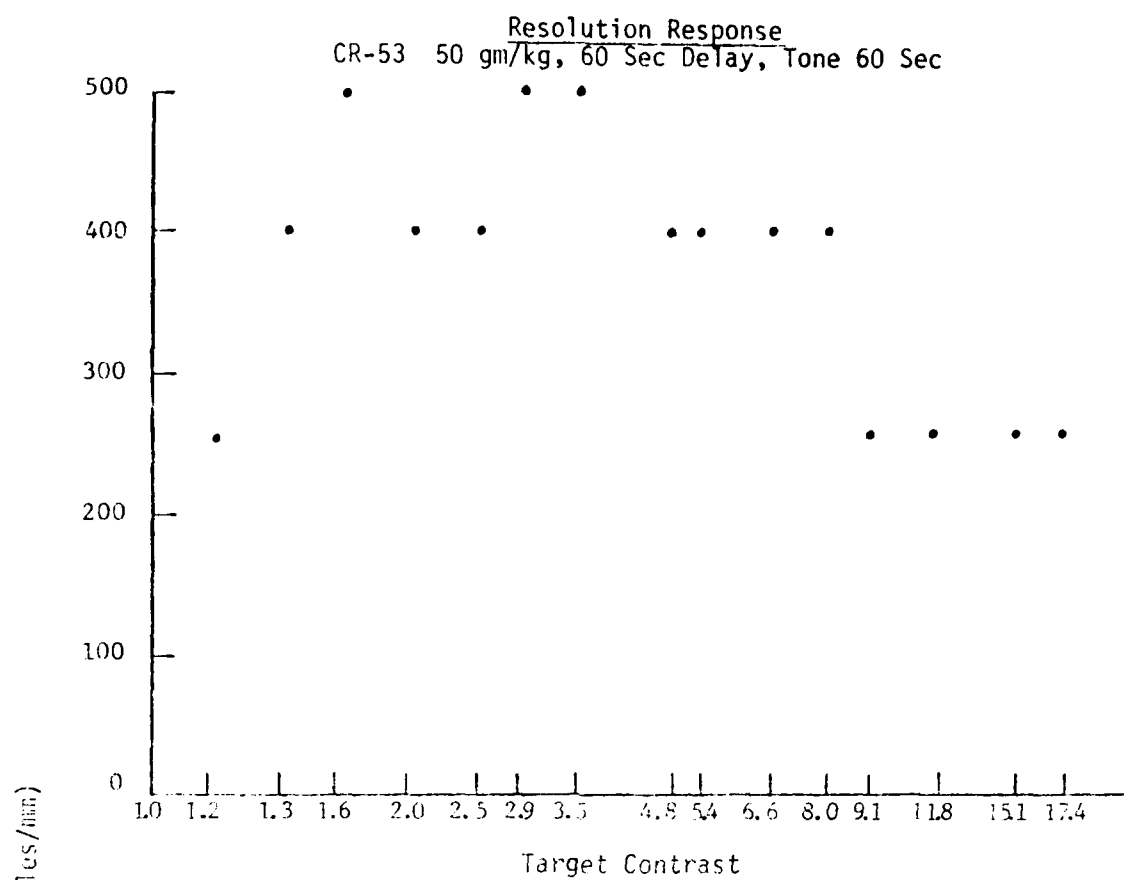


Figure 75

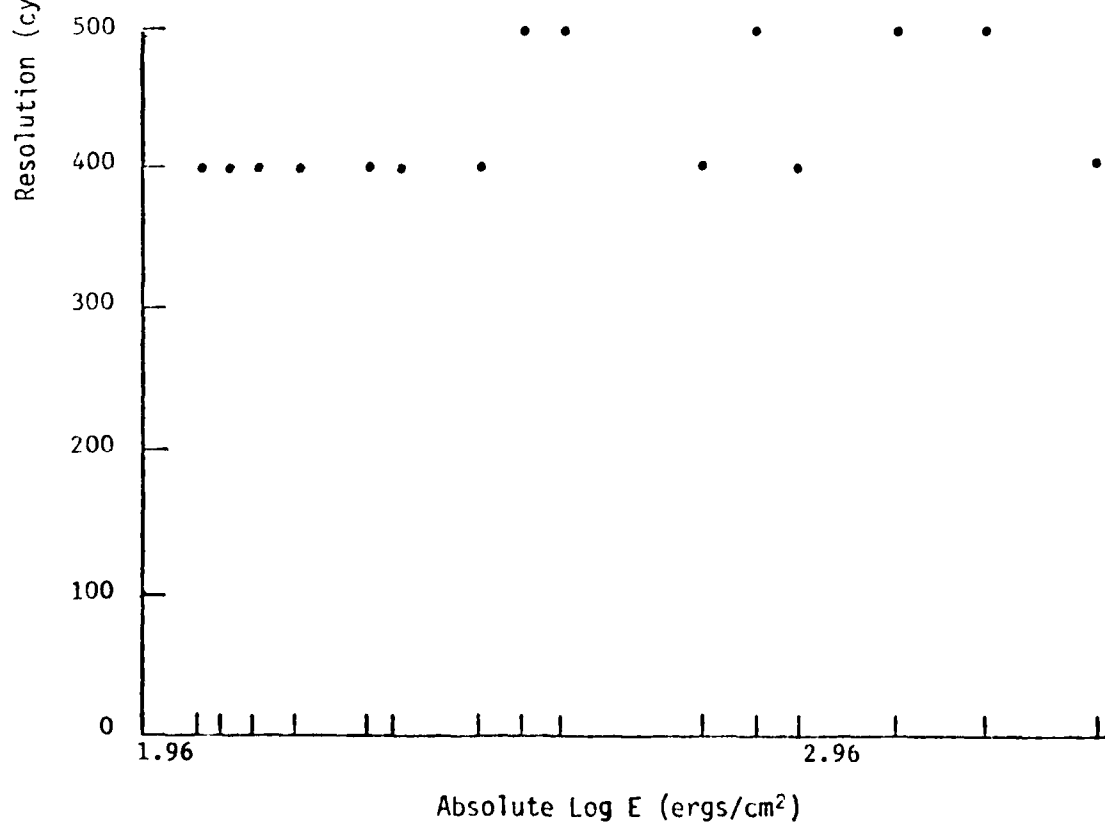
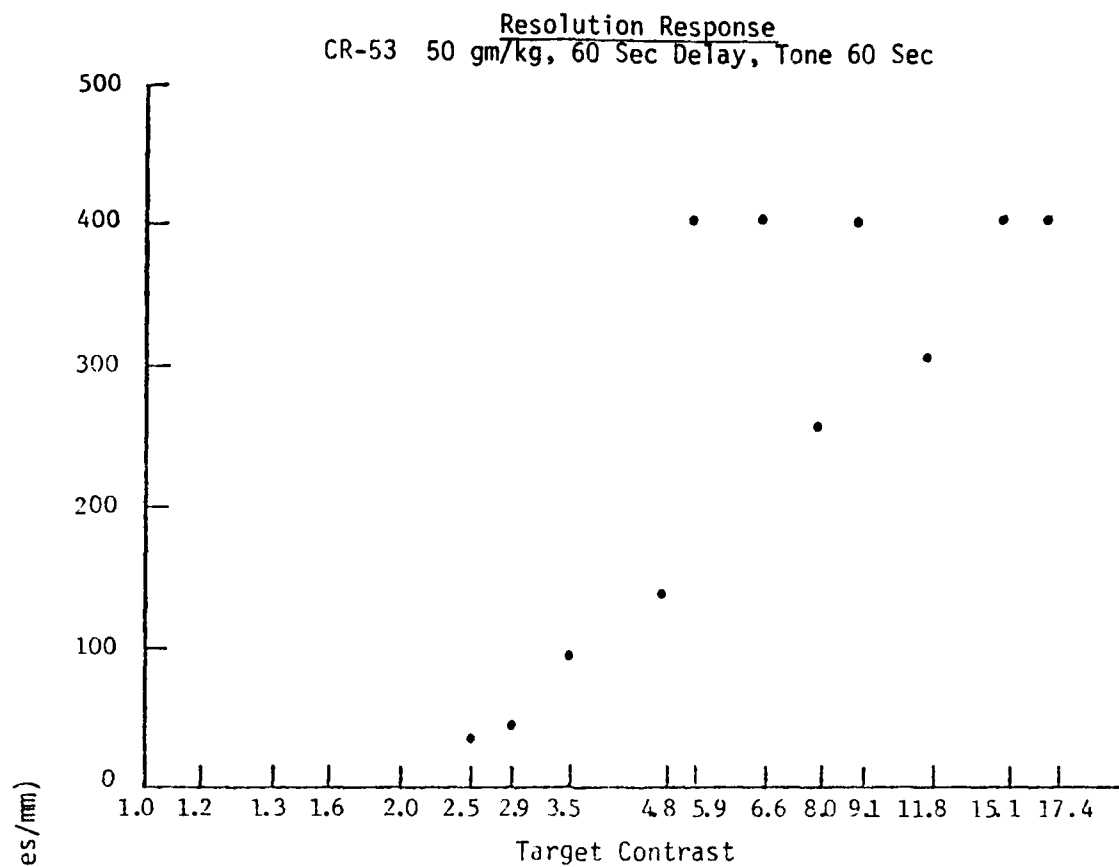
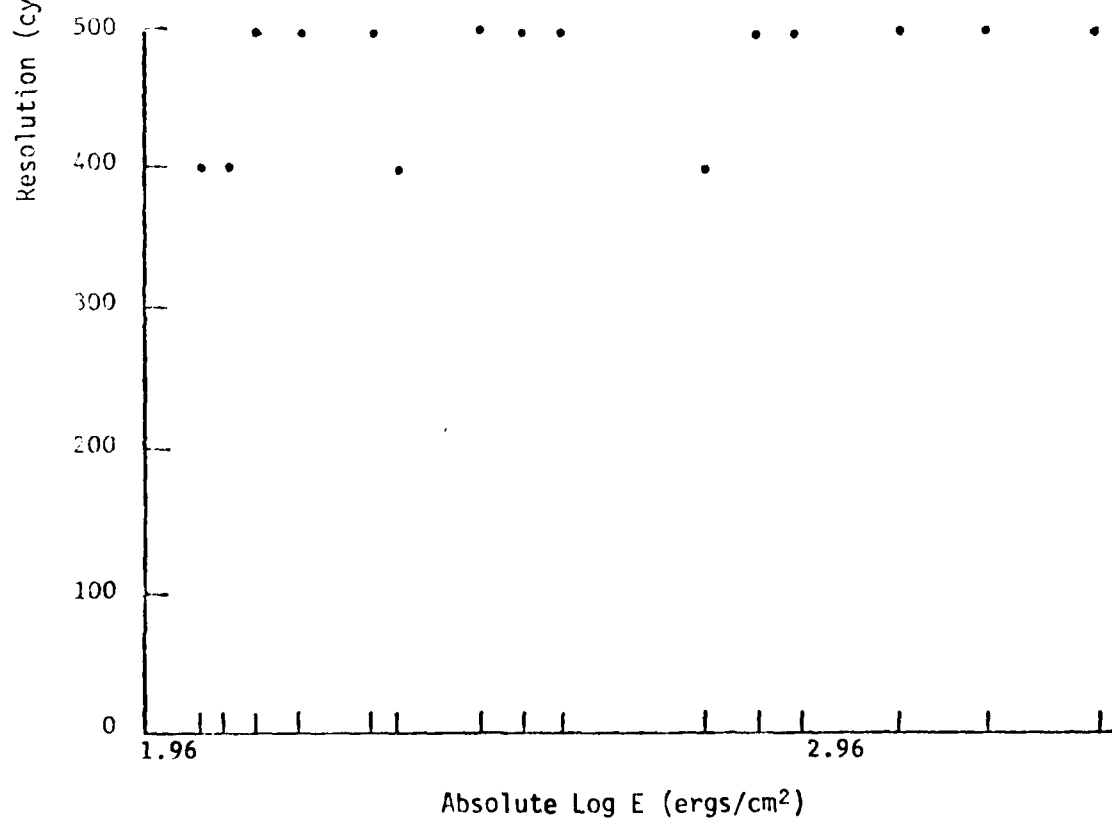
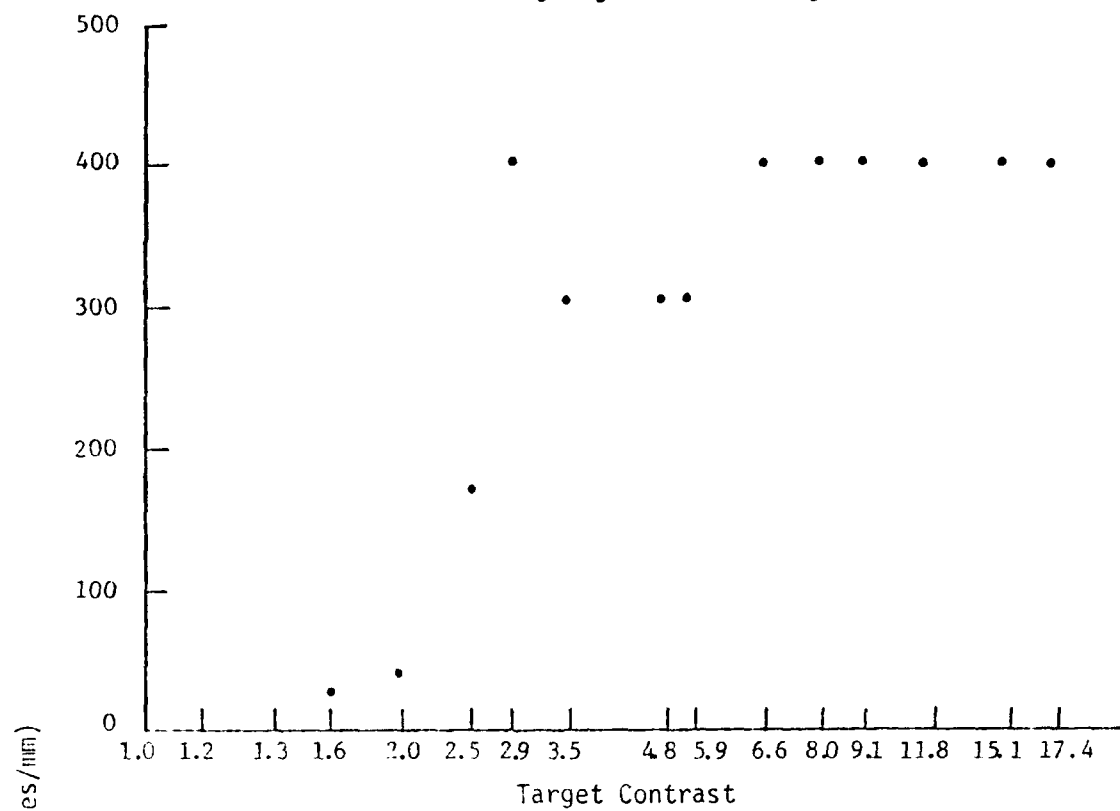


Figure 76

CR-53 100 gm/kg, 60 Sec. Delay, Tone 32 Sec.



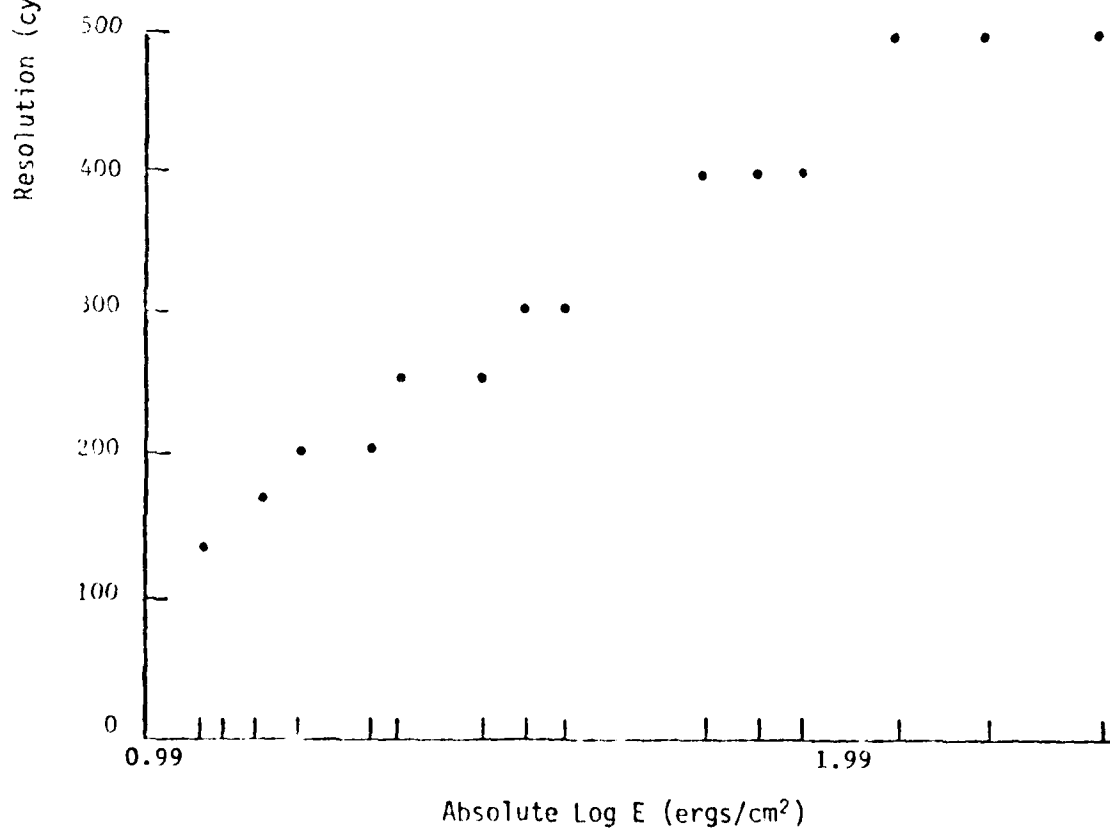
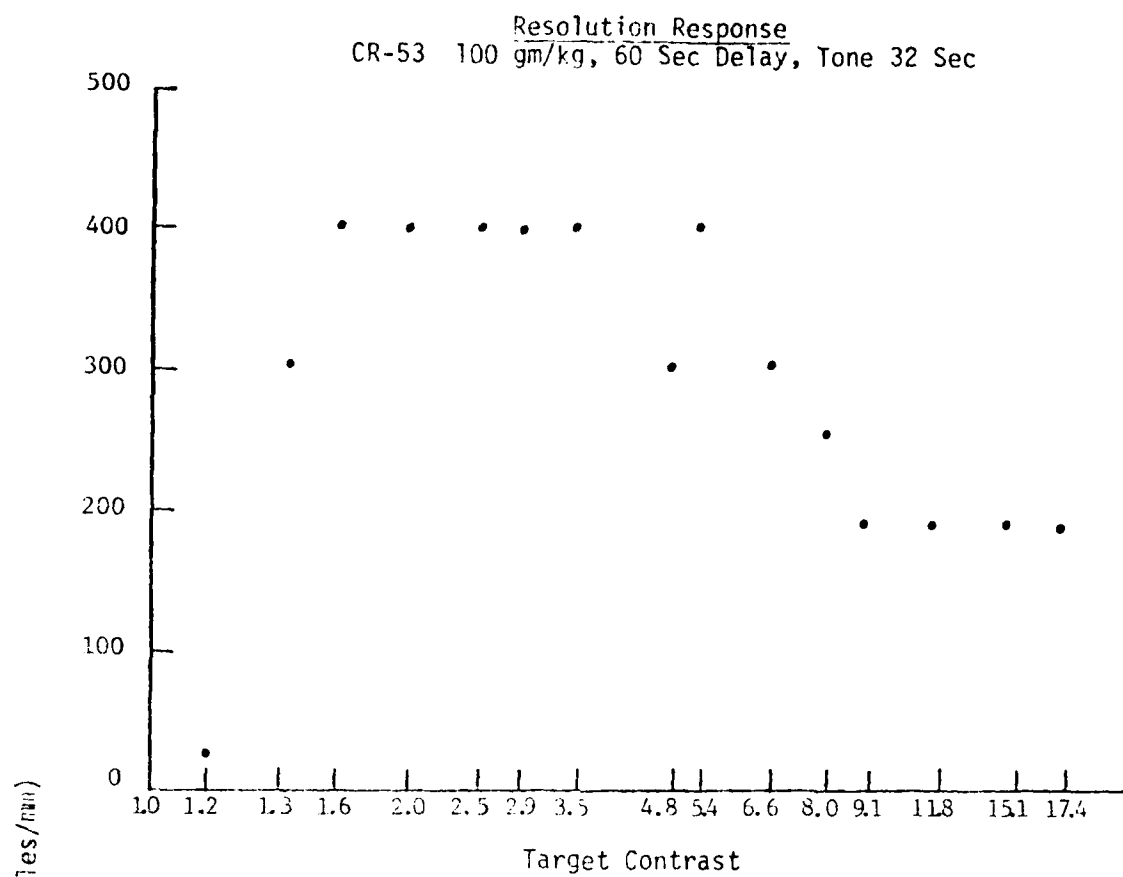


Figure 78

Resolution Response  
CR-53 100 gm/kg, 60 Sec. Delay, Tone 60 Sec.

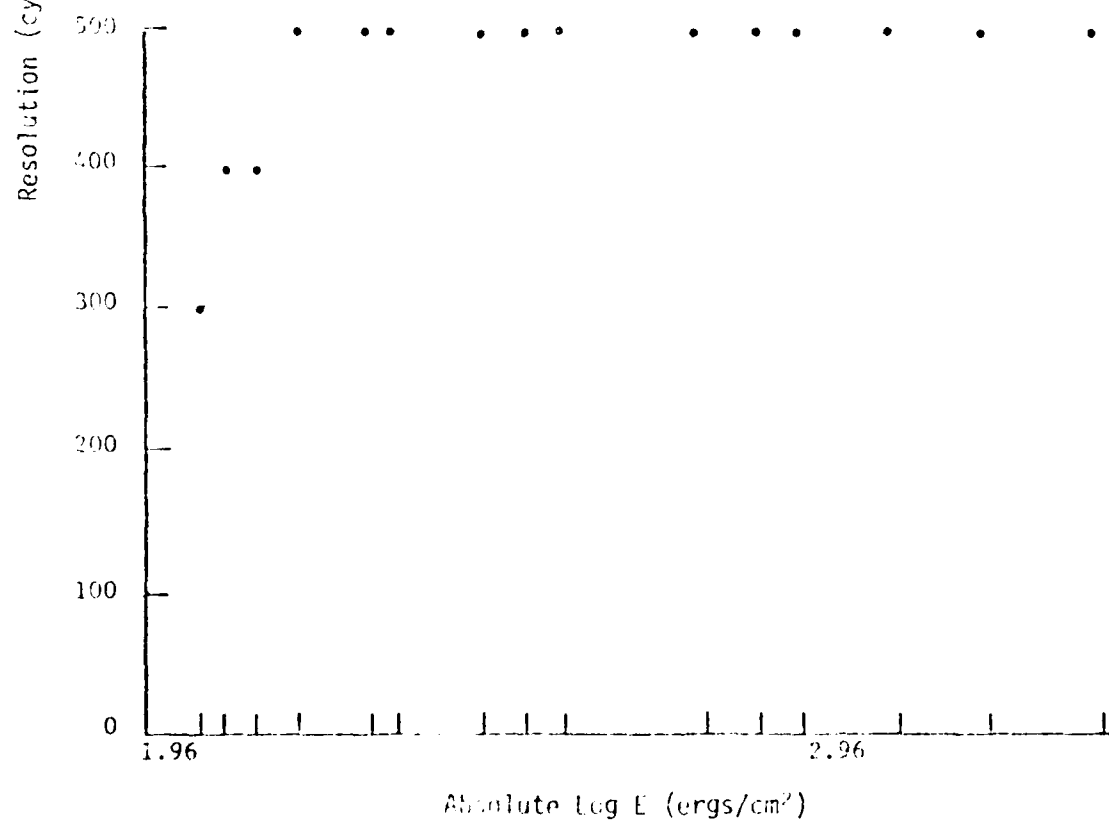
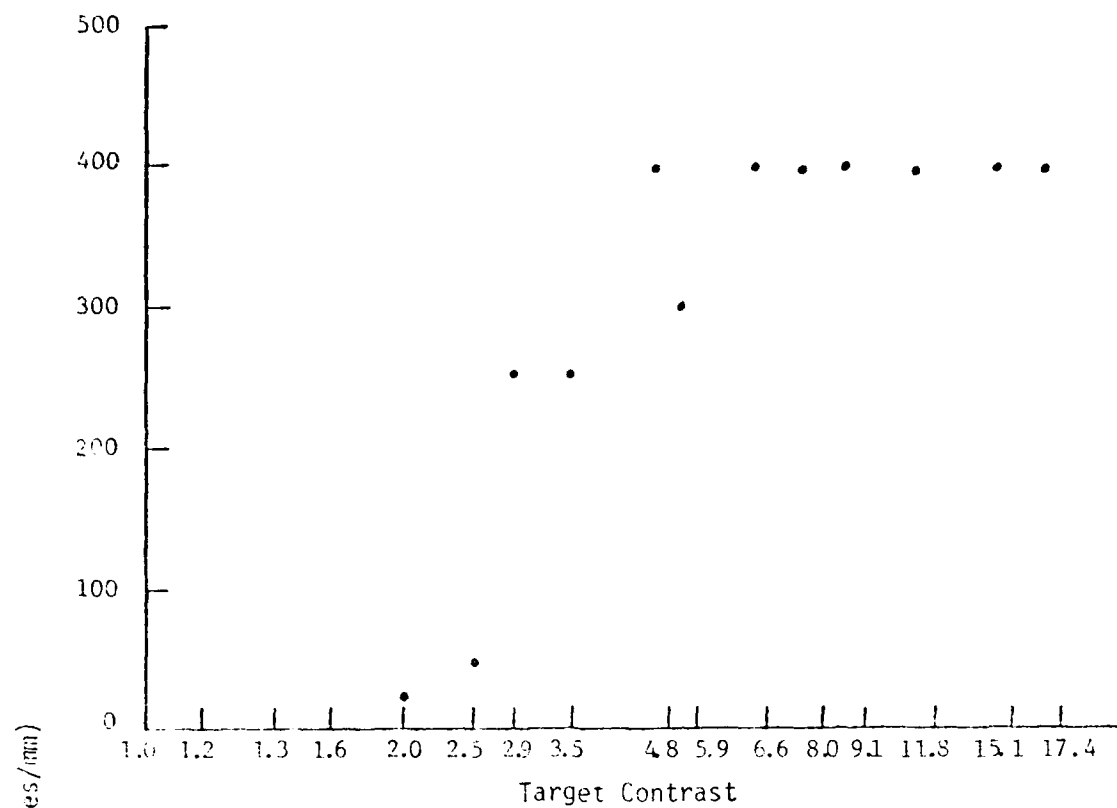


Figure 79

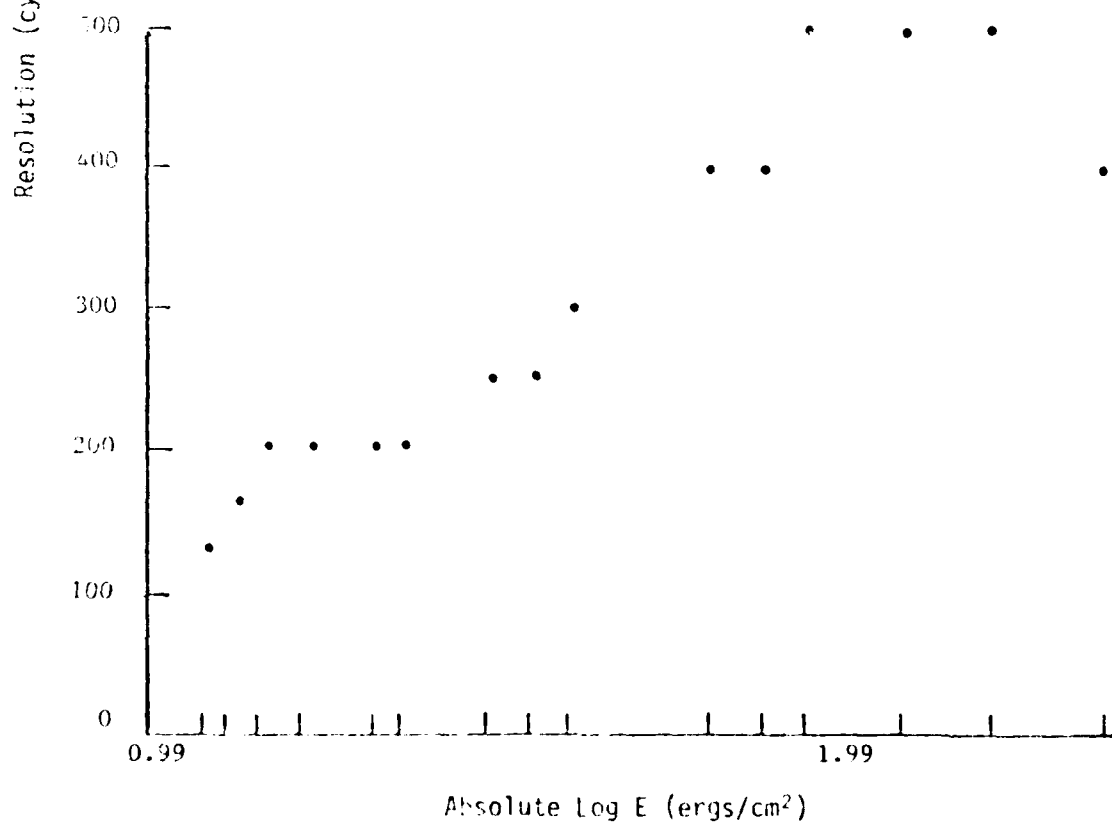
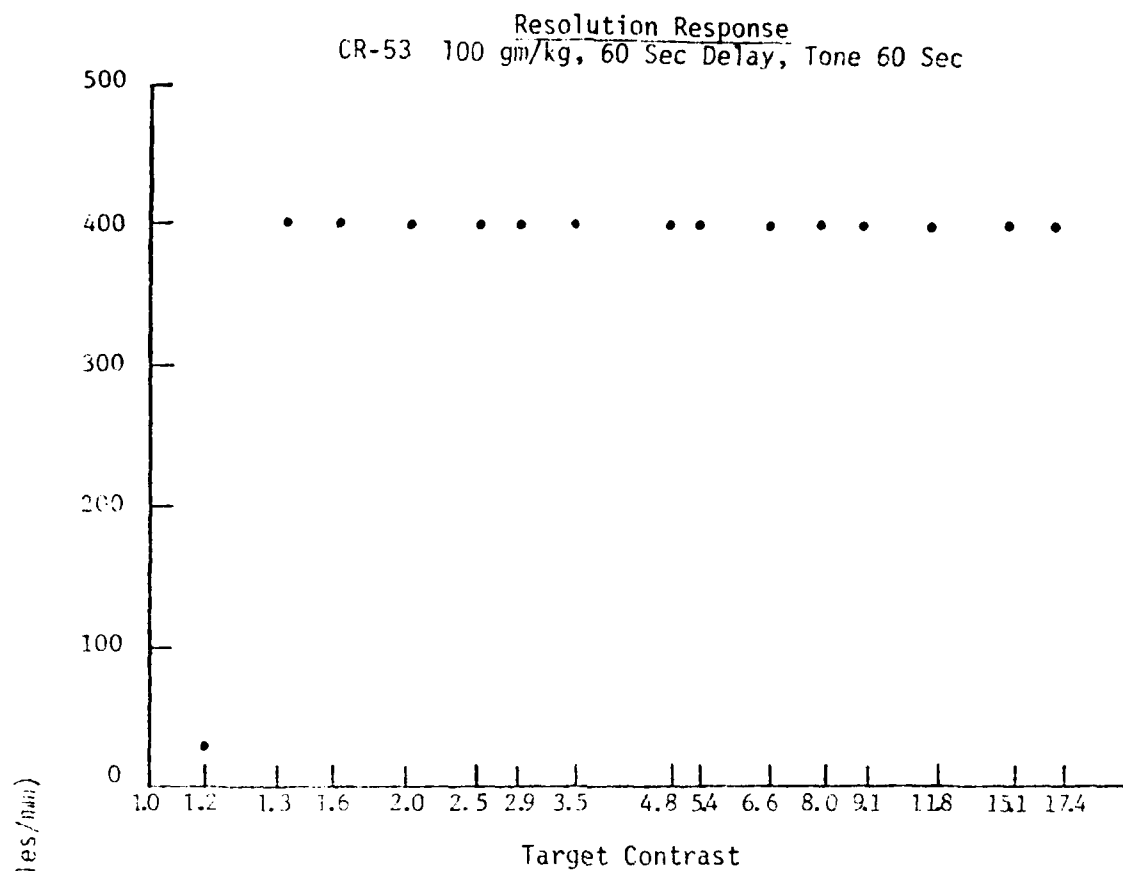


Figure 80

Resolution Response  
CR-53 200 gm/kg, 60 Sec Delay, Tone 32 Sec

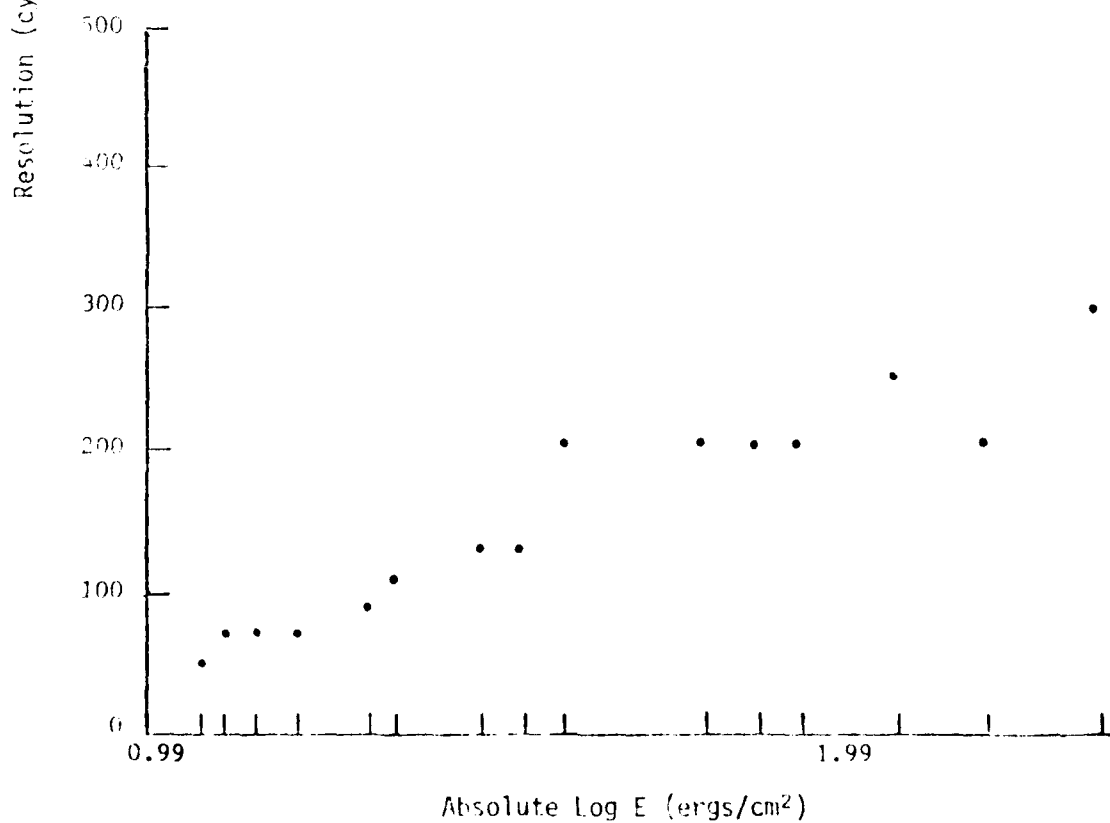
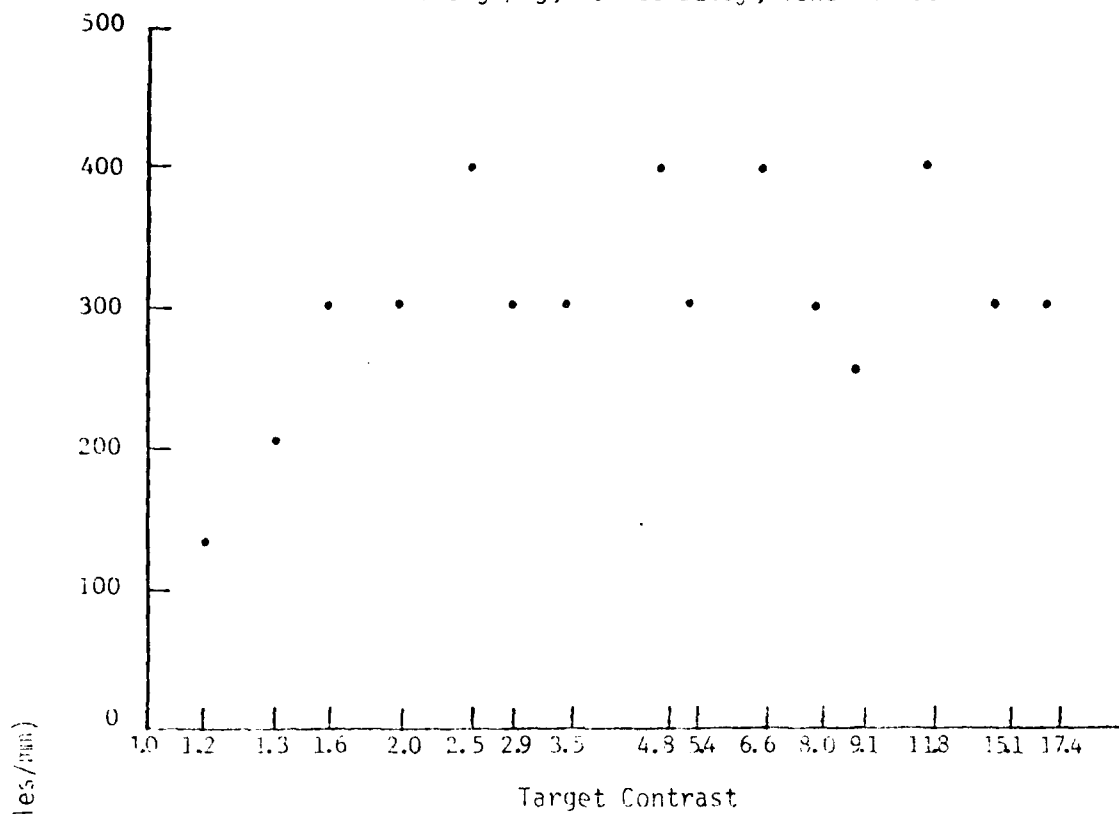


Figure 81

Resolution Response  
CR-53 200 gm/kg, 60 Sec. Delay, Tone 32 Sec.

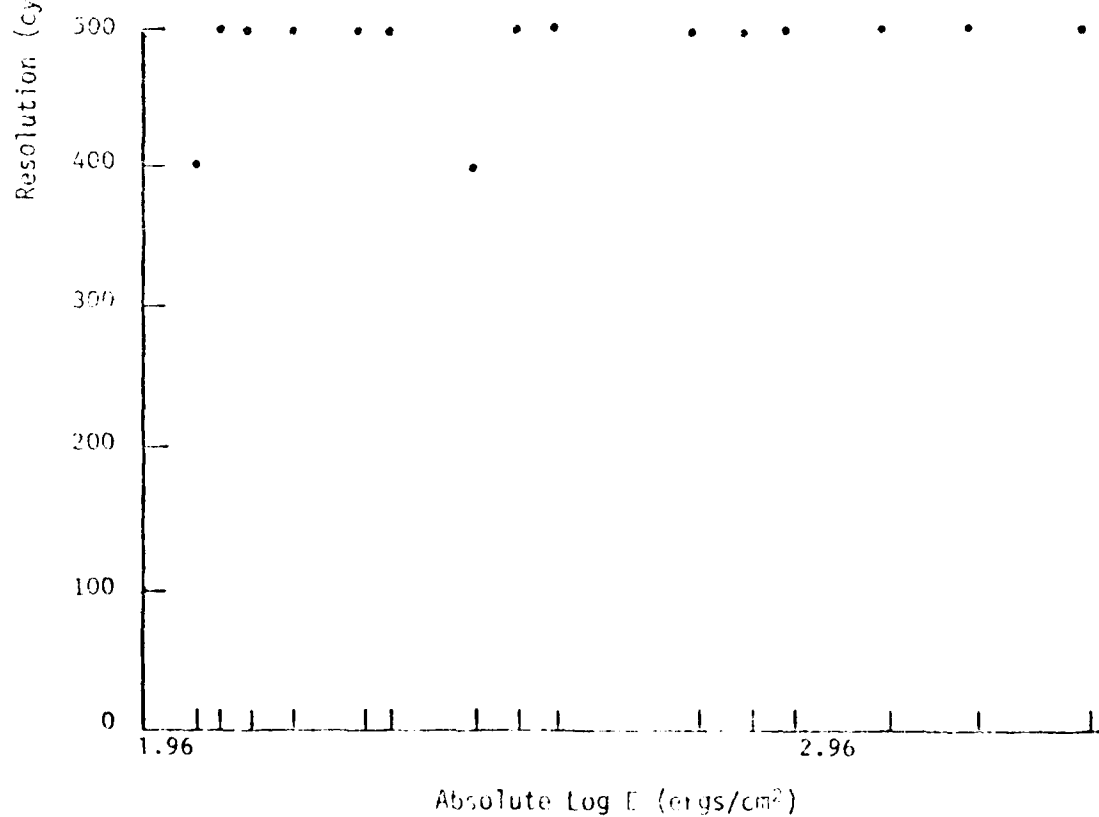
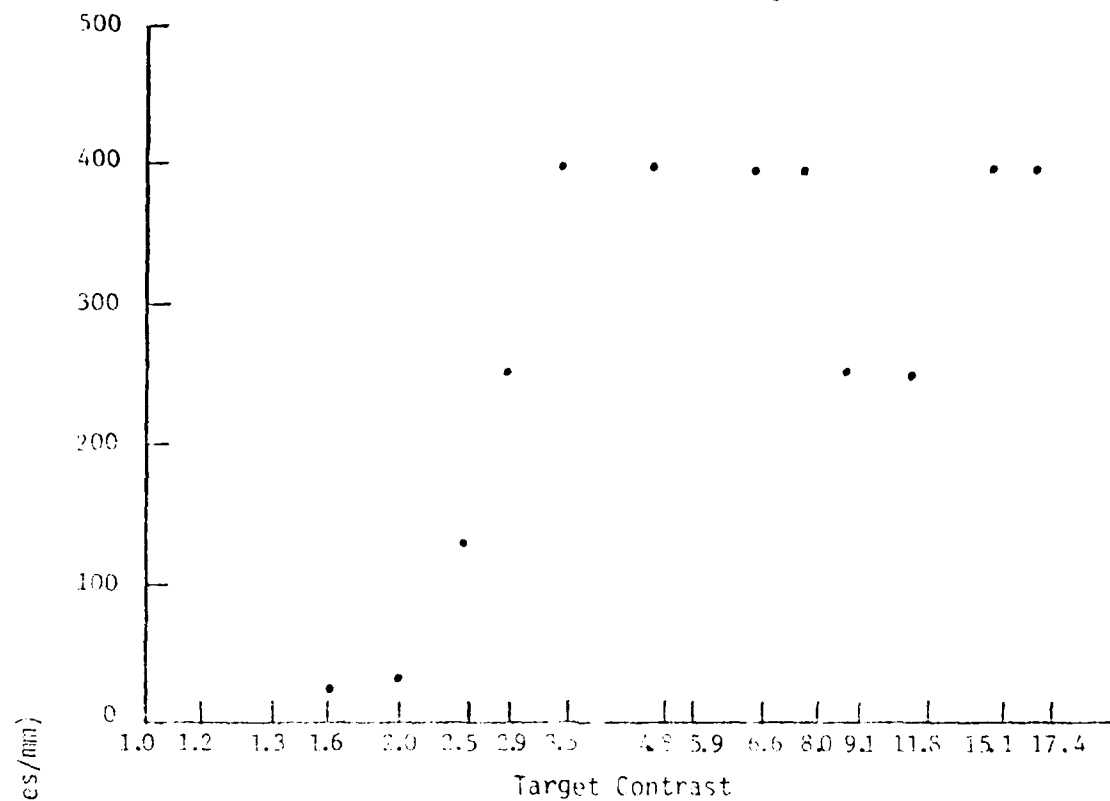


Figure 82

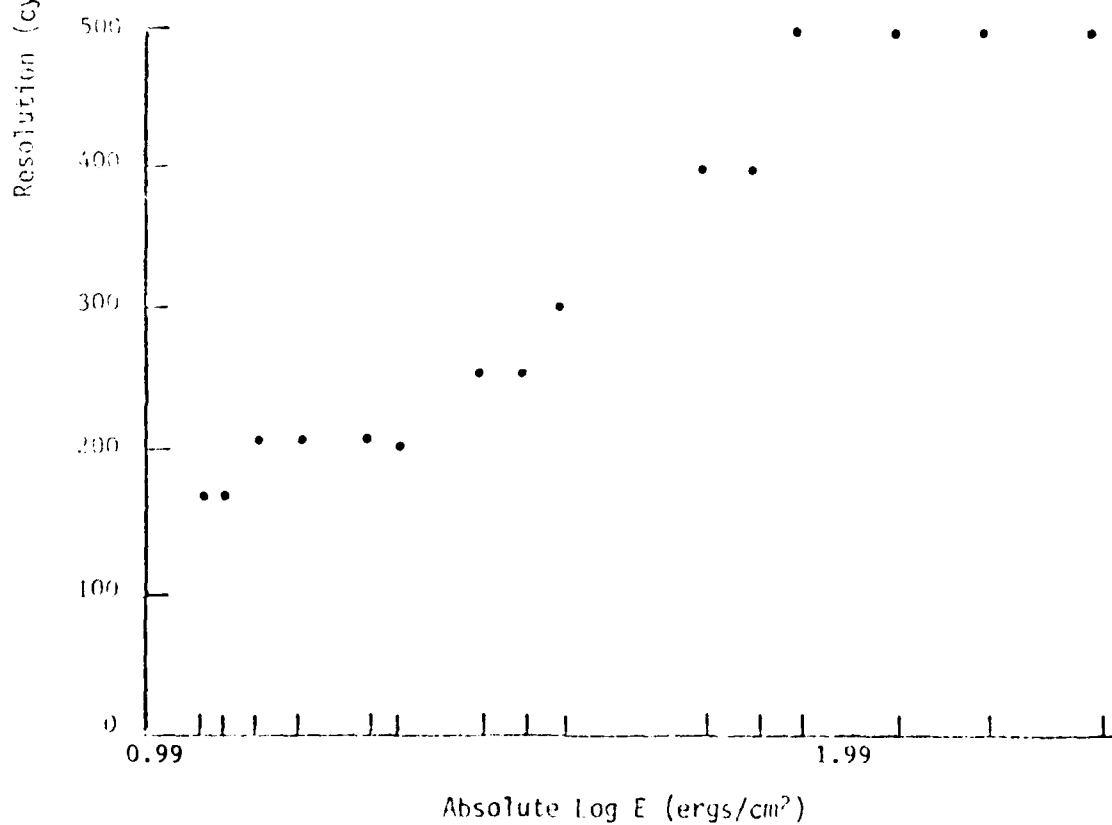
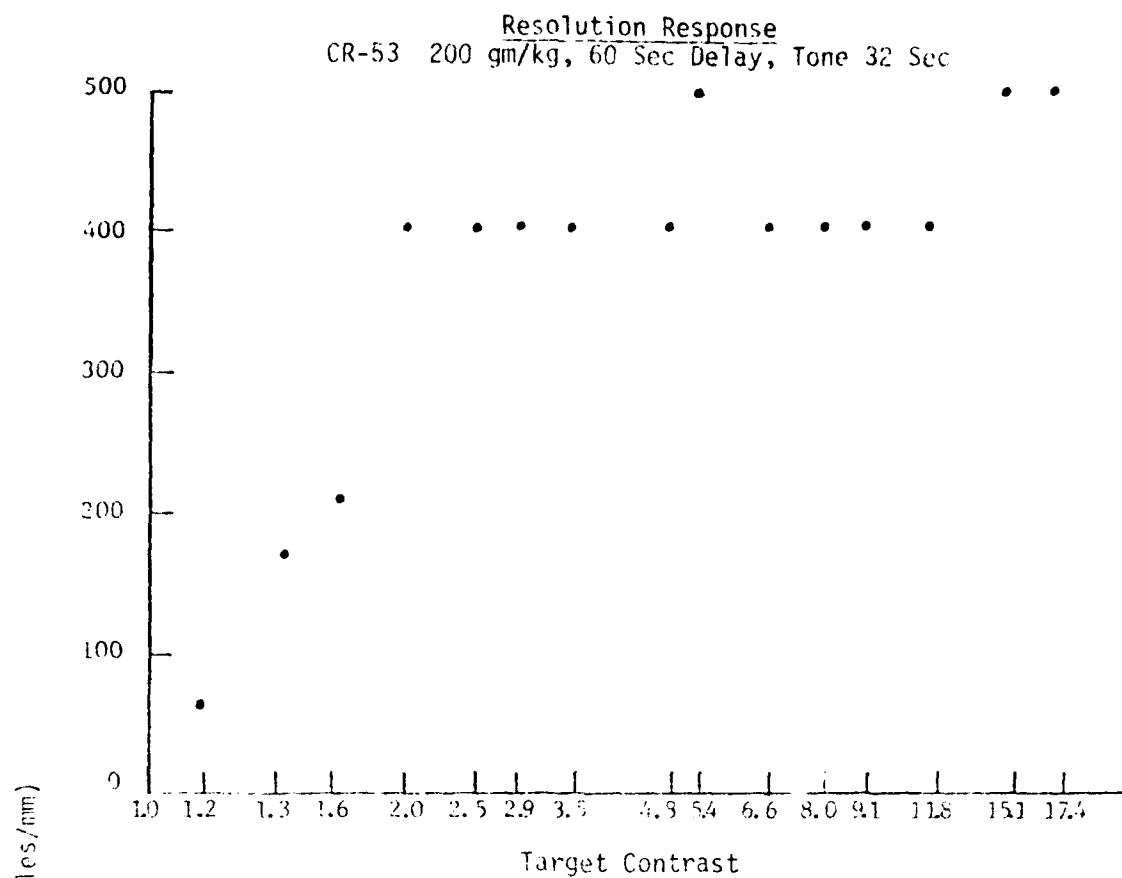


Figure 83

Resolution Response  
CR-53 200 gm/kg, 60 Sec. Delay, Tone 32 Sec.

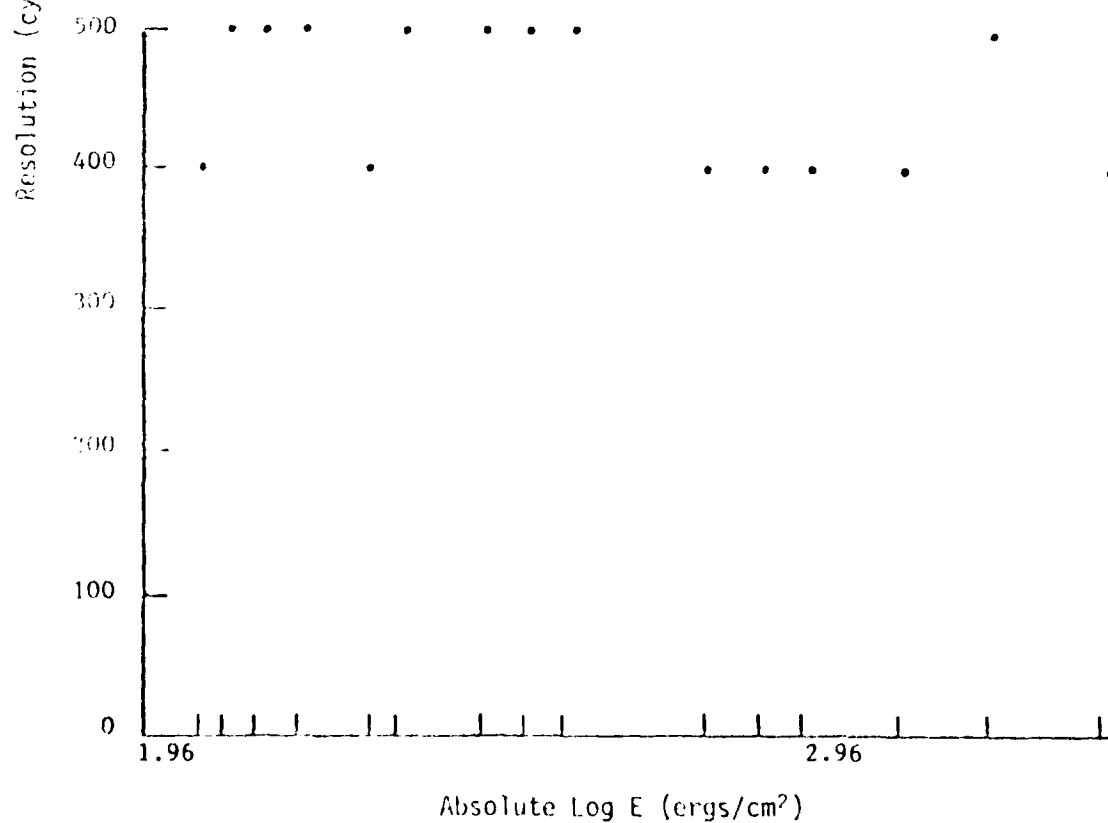
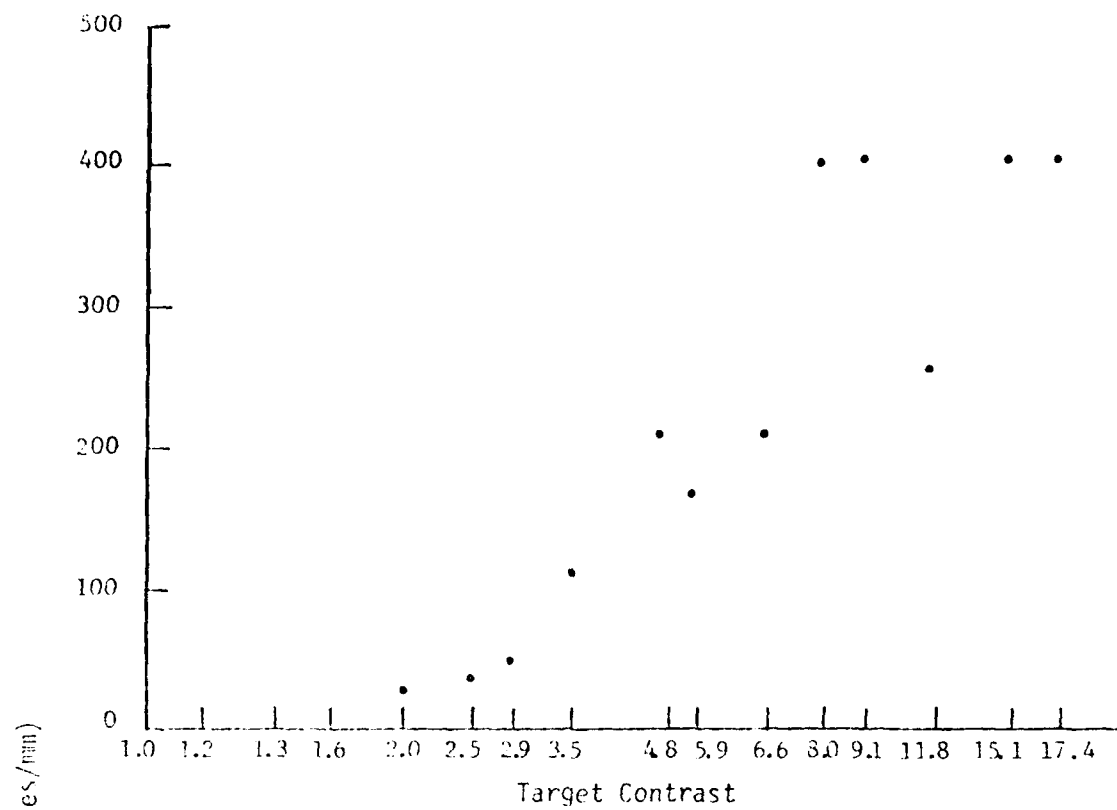


Figure 84

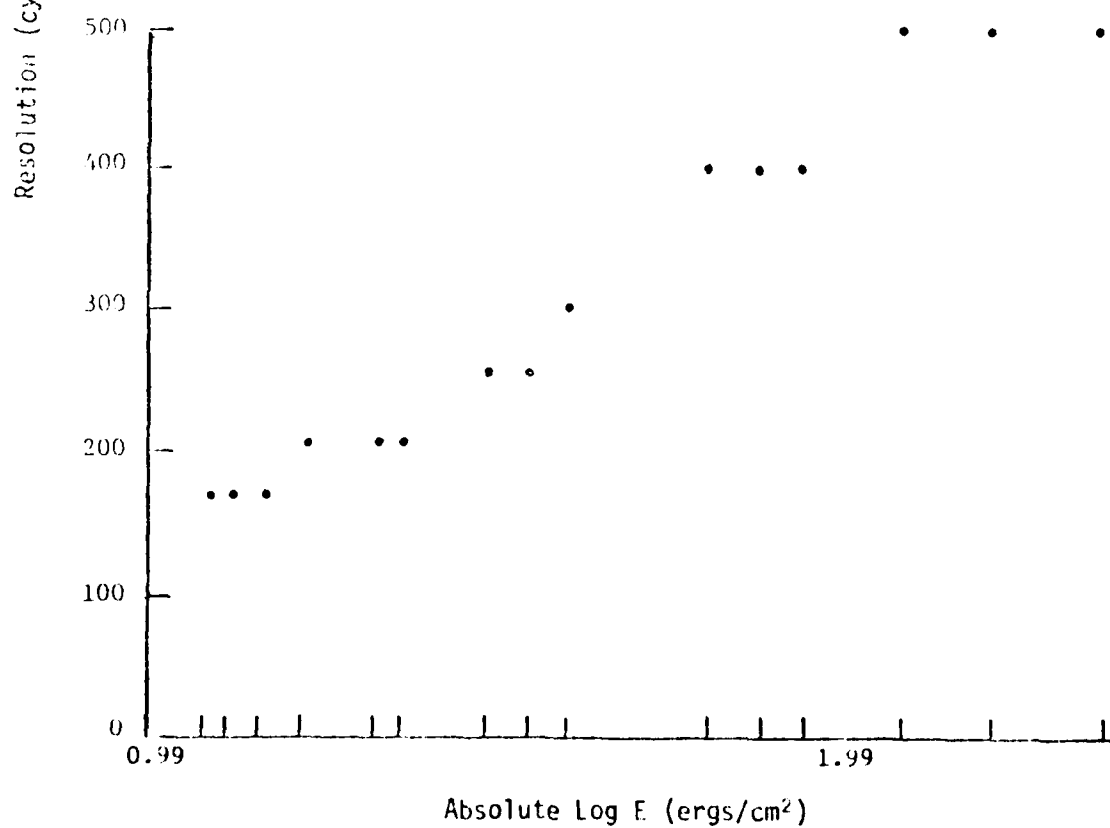
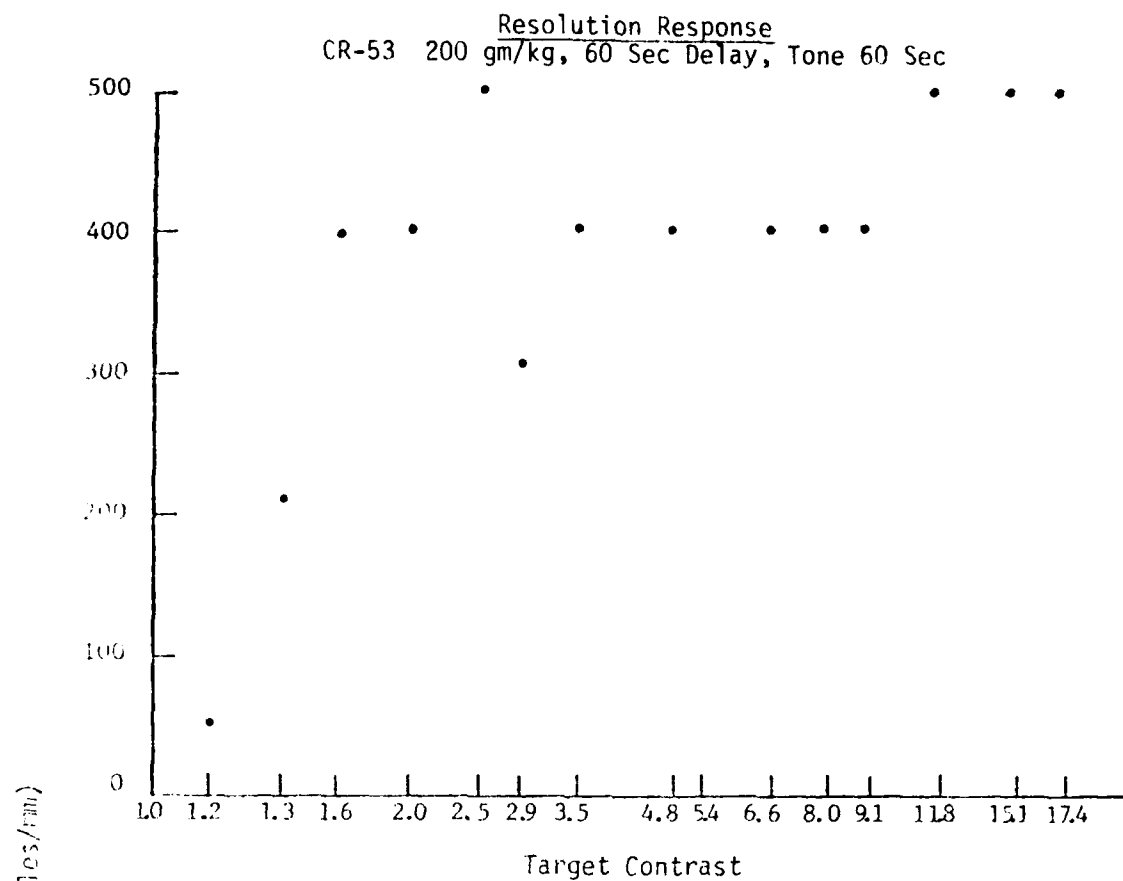


Figure 85

Resolution Response  
CR-53 200 gm/kg, 60 Sec. Delay, Tone 60 Sec.

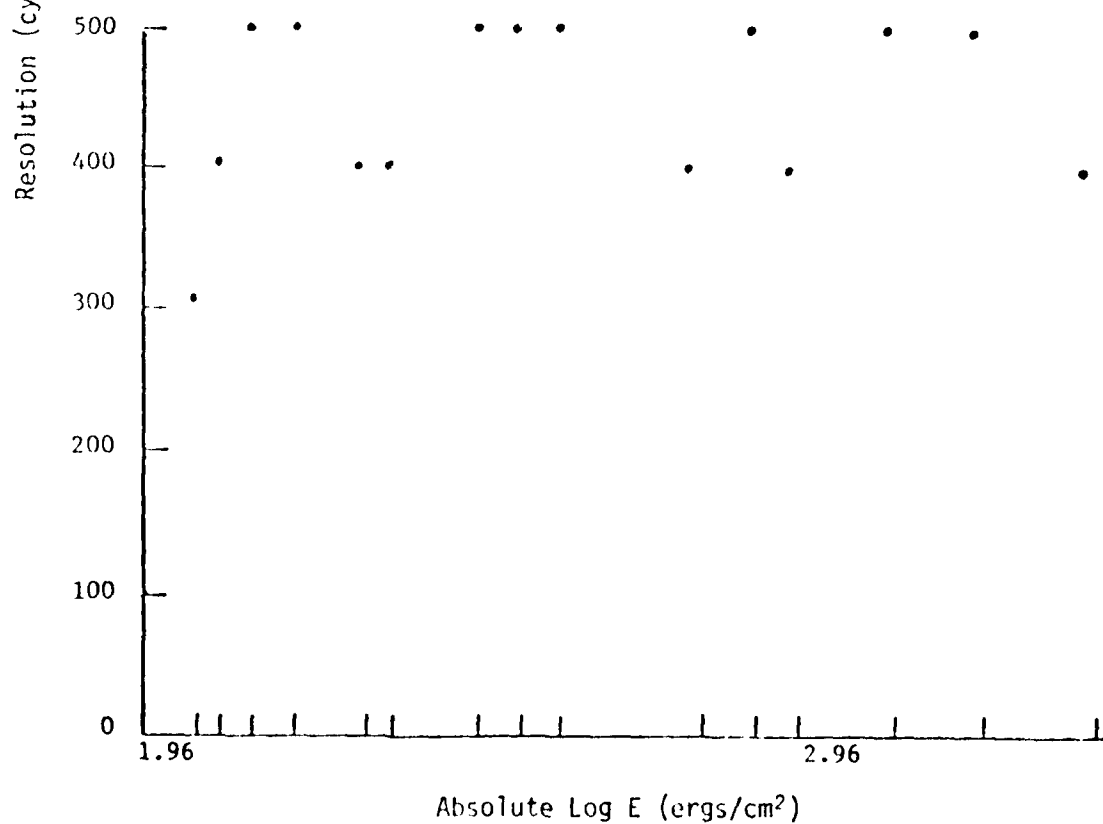
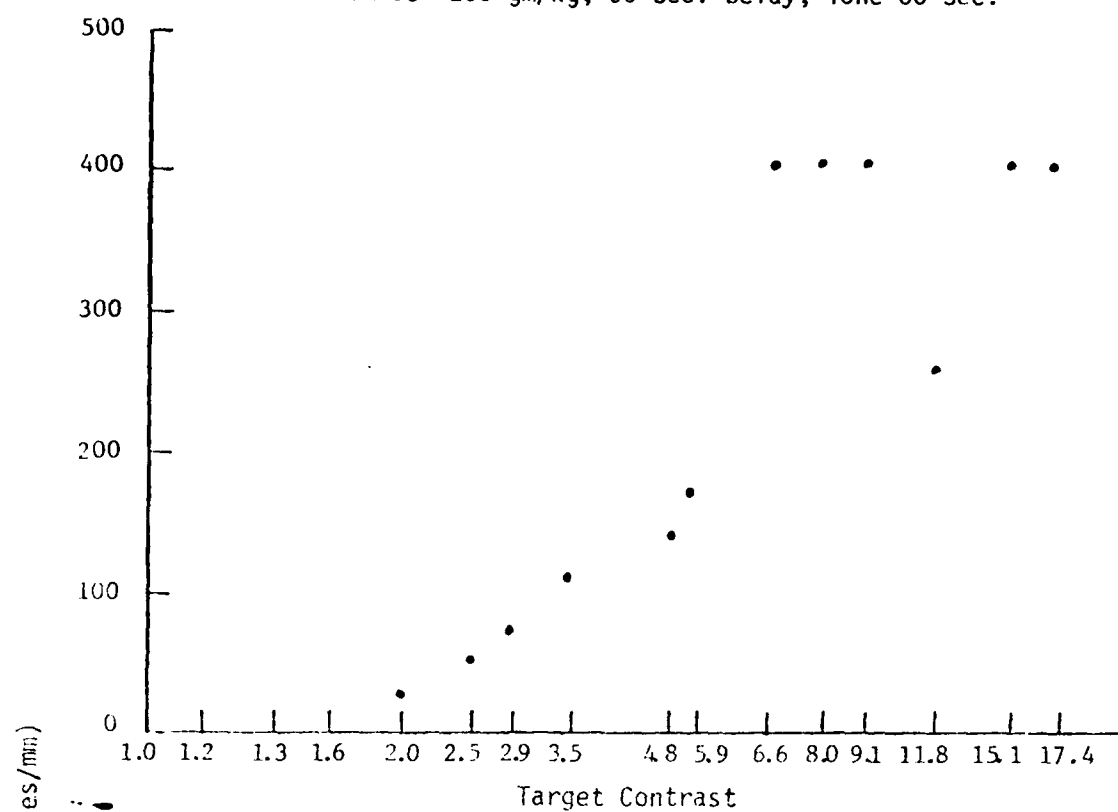


Figure 86

### 3.9.2 CR-42 Granularity

With CR-42 100 gm/kg, six traces were made and readings taken at 38.4  $\mu$ m. This spacing is sufficient to eliminate local correlation. Additionally, two traces were made parallel to the web direction of the film and four traces crossweb. It is believed that crossweb traces may have more deviation than web direction traces. Thus, this is a conservative procedure. Below are listed the granularity determinations for each trace as well as the pooled granularity for all six traces. Pooling was obtained by combining the sums of squares for all traces, then dividing by the total degrees of freedom (750) and extracting the square root.

<u>Trace</u>	<u>Granularity</u>
1	21.6
2	20.6
3	27.0
4	21.2
5	16.0
6	20.4
Pooled Data	21.4 (750 D.F.)

### 3.9.3 CR-53 Granularity

A similar procedure was used in obtaining the granularity associated with toner CR-53 and the data are listed below:

<u>Trace</u>	<u>Granularity</u>
1	13.4
2	16.9
3	14.0
4	15.0
5	16.12
Pooled Data	14.97 (450 D.F.)

It should be pointed out that these determinations were made using manual calculations; thus the data base is approximately half that normally

used. However, determination of the standard deviations based on an infinite number of determinations is quite simple. The "f" small t statistic is appropriate and would increase the granularity by 1%. The microdensitometer traces are shown in figures 87 through 90.

### 3.10 Acutance

The manual precision system was used for this determination. Once again, CR-42 and CR-53 were used at concentrations of 50, 100, and 200 gm/kg. The evaporated target was used as an available approximate to a knife edge exposure system. This is a reasonable procedure since the evaporated Inconel is thinner than a razor blade, even near or at the edge. In keeping with general practice, a place on the target was chosen having a wide area of clear glass abutting a wide area of density approximately 1.3 on the target. The edge was measured.

Measurements were made at Coulter Systems Corporation using a Joyce Loebel microdensitometer Mark IIIC, Serial No. 584. The acutance measured was sufficiently high that corroboration of the determination was desirable. Arrangements were made to trace all six samples on a Mann 1140 microdensitometer at Itek Corporation by an experienced analyst. Traces were run on all six samples at Itek Corporation. The acutance determinations based on these traces were higher than from the Joyce Loebel instrument, as expected.

#### 3.10.1 Procedure

For both instruments the procedure was quite similar. An effective efflux slit of 1  $\mu\text{m}$  was used. The smallest influx slit on the Joyce Loebel was approximately 4.5  $\mu\text{m}$ , but approximately 1.5  $\mu\text{m}$  with the Mann. In both cases a slit length greater than 100  $\mu\text{m}$  was used ( $\sim$  150  $\mu\text{m}$  with the Joyce

Loebl, and 175  $\mu\text{m}$  with the Mann). Calibrated diffuse density was obtained by correlation of diffuse density from a Macbeth TD-518 densitometer with chart density obtained with the same scanning geometry used for the edge trace. The chart travel in  $\mu\text{m}$  was calibrated against an object of known dimension. For instance, with the Joyce Loebl several cycles of a 10 cycle per mm target were traced, and the mean distance in  $\mu\text{m}$  between the mid points of the edge traces was used. On the Mann, the illuminating and pick-up objectives were 10X, 0.25 N.A., operating at approximately 20X.

### 3.10.2 Results

The acutance determinations for all six samples are listed below:

<u>Sample</u>	<u>Acutance</u>	
	<u>Joyce Loebl</u>	<u>Mann</u>
CR-42 50 gm/kg	$1.6 \times 10^4$	$4.1 \times 10^4$
CR-42 100 gm/kg	$9.6 \times 10^3$	$3.8 \times 10^4$
CR-42 200 gm/kg	$9.7 \times 10^3$	$1.5 \times 10^4$
CR-53 50 gm/kg	$2.0 \times 10^4$	$3.3 \times 10^4$
CR-53 100 gm/kg	$2.5 \times 10^4$	$5.7 \times 10^4$
CR-53 200 gm/kg	$3.0 \times 10^4$	$6.0 \times 10^4$

The Mann instrument is better than the Joyce Loebl, particularly in reduction of flare which can greatly affect high contrast edge traces. This acutance as determined from the Mann instrument should be used. The microdensitometer edge traces are shown in figures 91 through 102.

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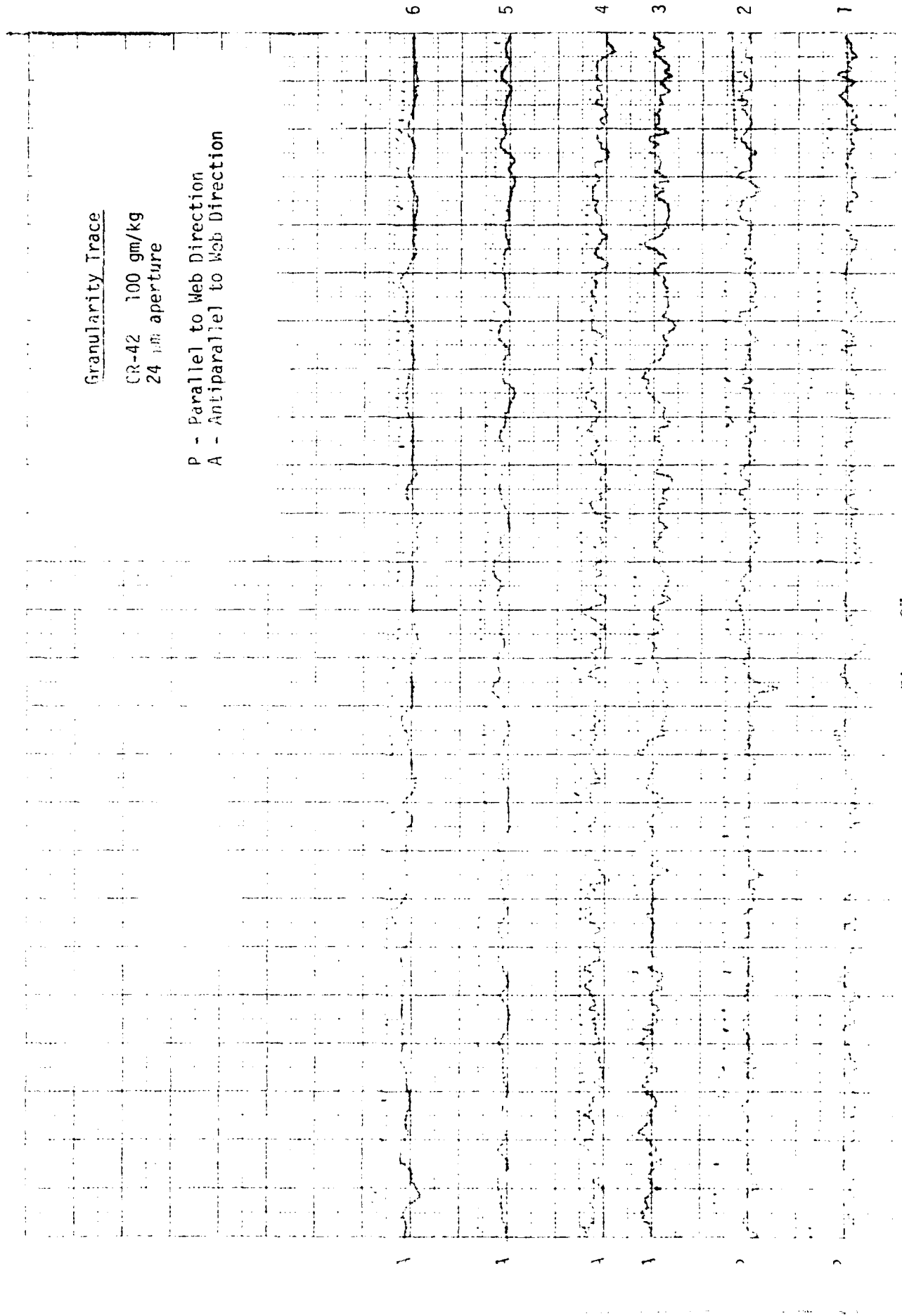


Figure 87

461510

Granularity Trace

CK-53 100 gm/kg  
24  $\mu$ m aperture

Parallel to Web Direction  
"Best" Area

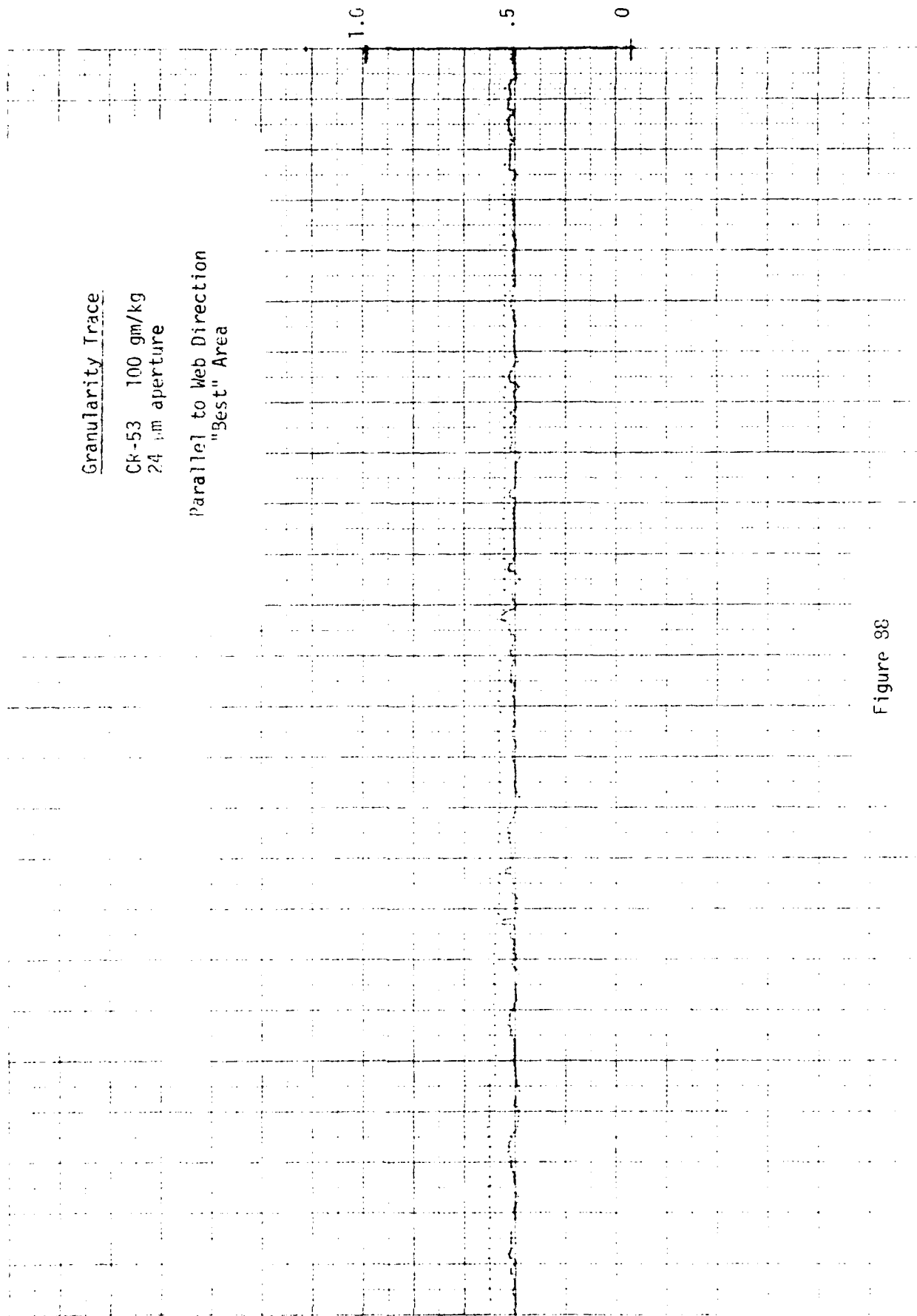


Figure 98

Granularity Trace

CR-53 100 gm/kg  
24 in aperture

Perpendicular to Web Direction  
"Best" Area

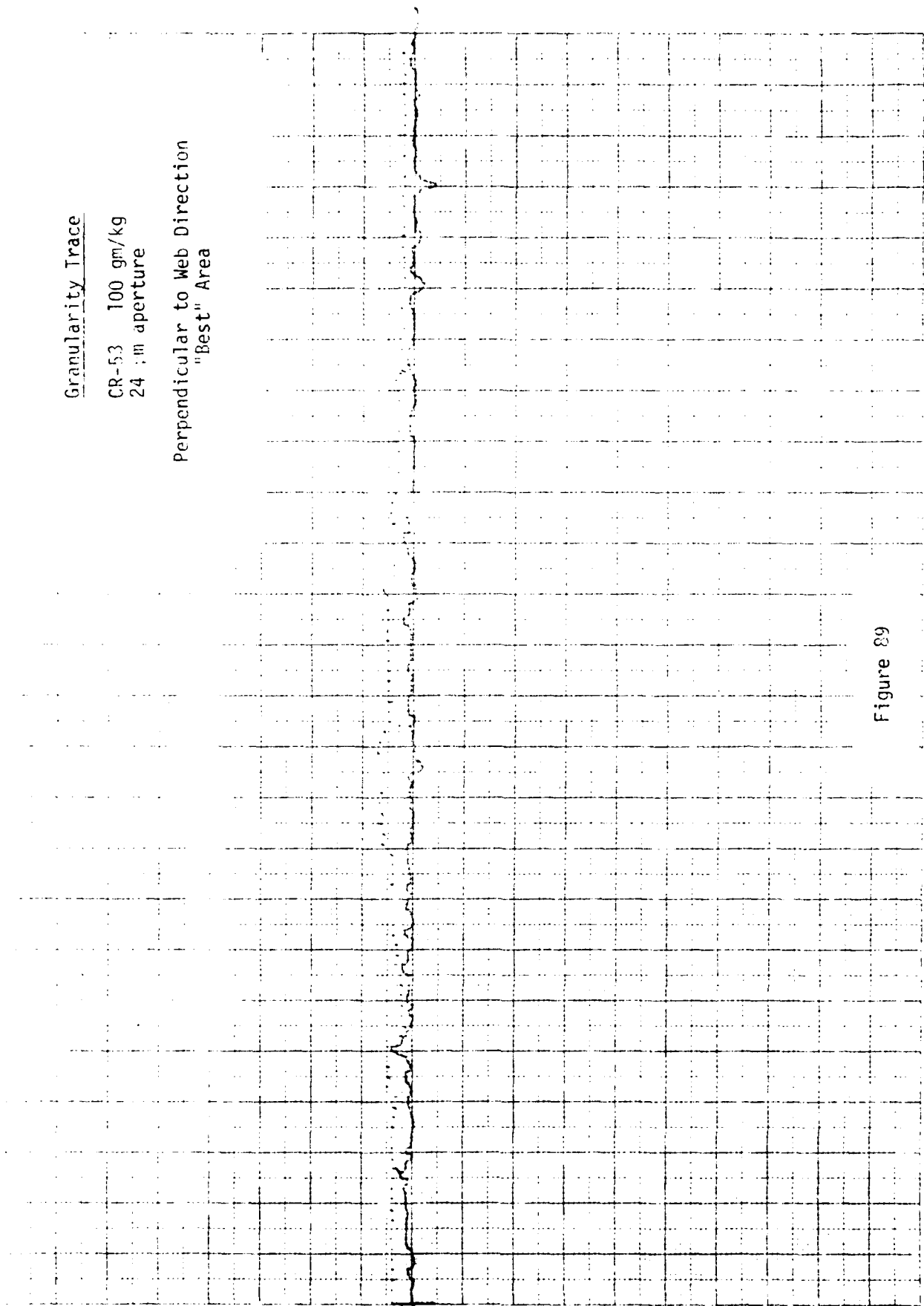


Figure 89

Granularity Trace

CR-53 100 gm/kg  
24  $\mu$ m aperture

Perpendicular to Web Direction  
"Worst" Area

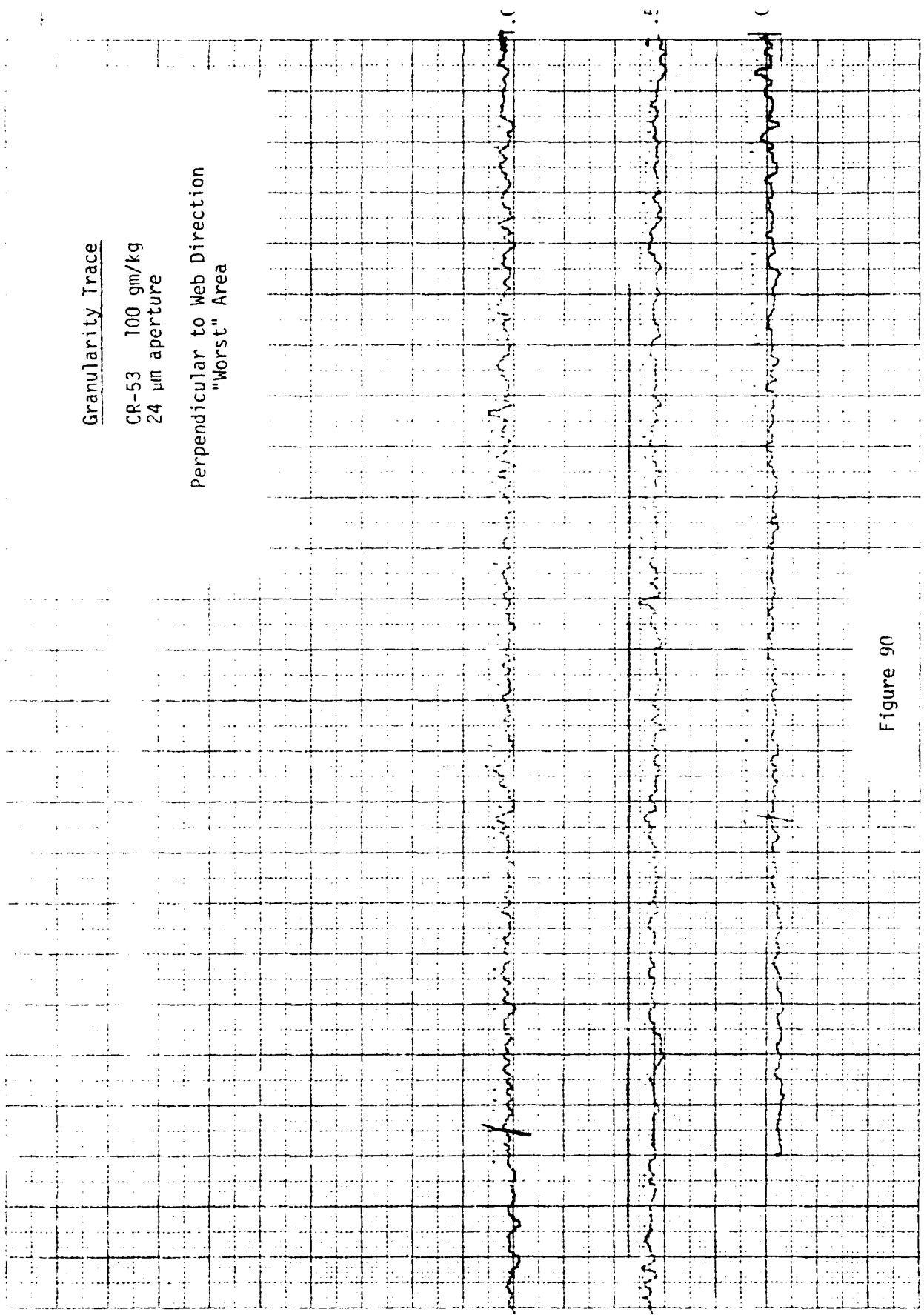


Figure 90

4b1510

Edge Trace

CR-42 50 gm/kg

Joyce Loeb1

↓  
2.7  $\mu$ m  
↑

Figure 91

161310

100 gm/kg

Edge Trace

CR-42 100 gm/kg

Joyce Loeb1

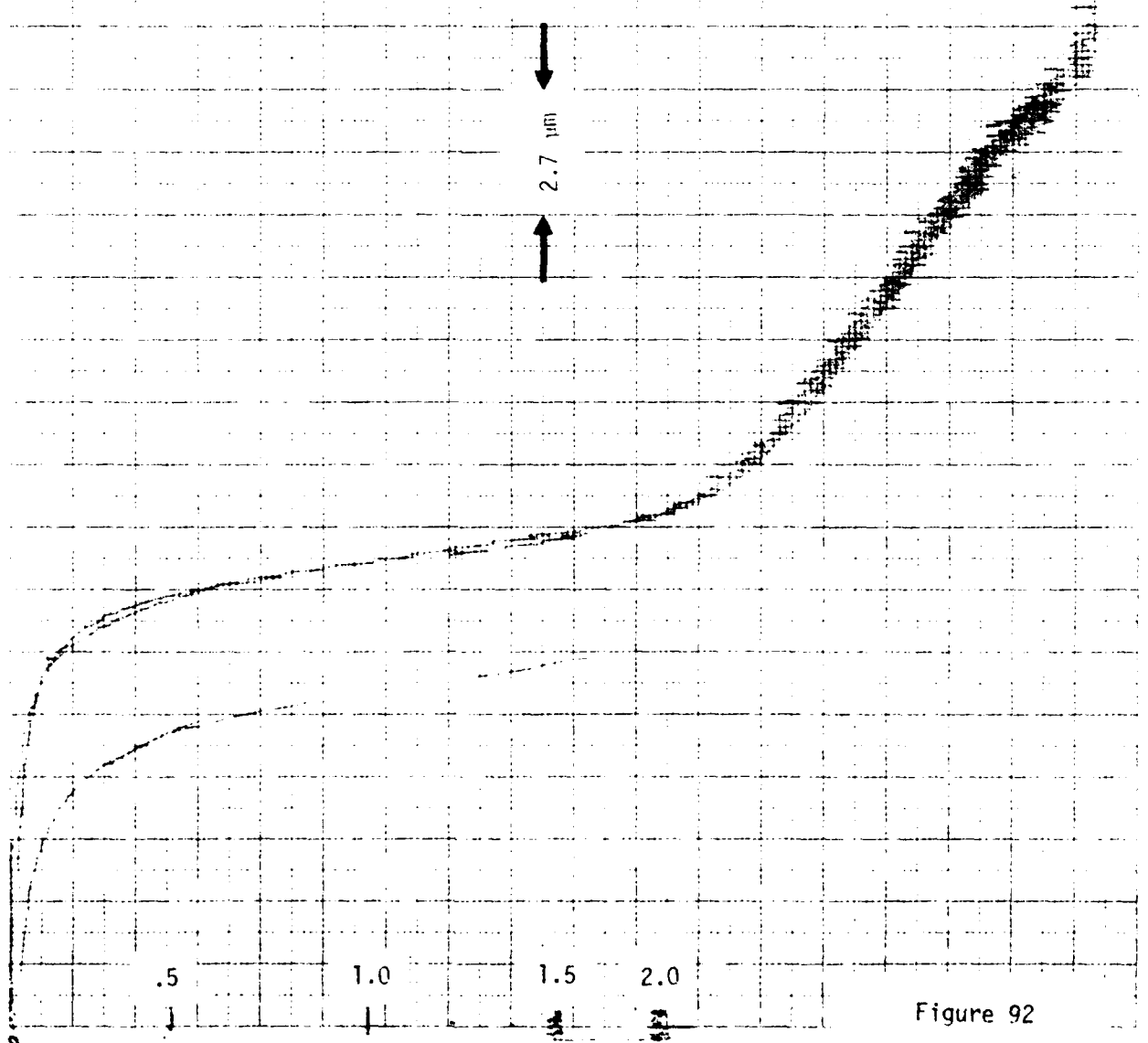


Figure 92

461510

1902 1 1 10 00 00 00 00 00

Edge Trace

CR-42 200 gm/kg

Joyce Loeb1

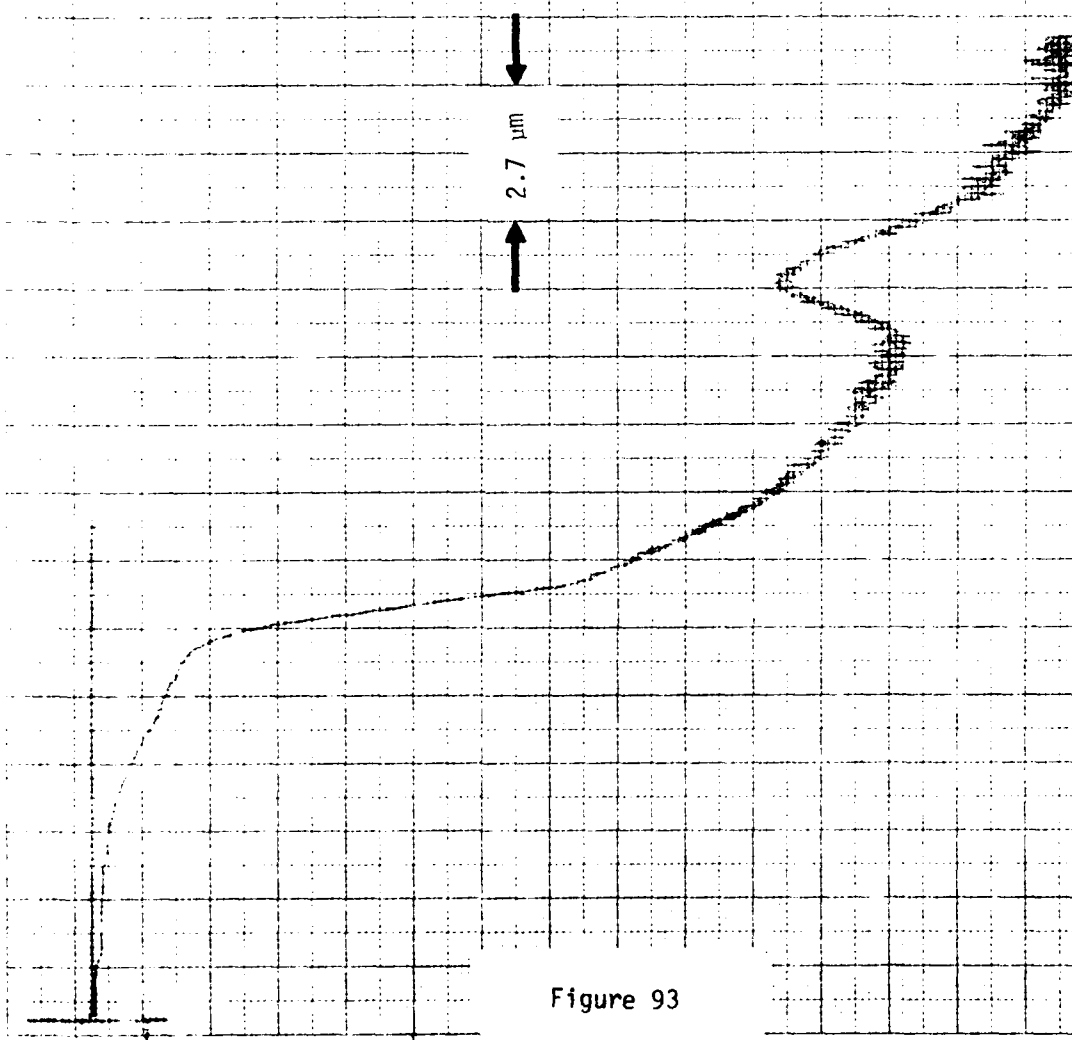


Figure 93

46 1510

100% 100% 100% 100%

Edge Trace

CR-53 50 gm/kg

Joyce Loeb1

↓  
2.7  $\mu$ m  
↑

Figure 94

Edge Trace

CR-53 100 gm/kg

Joyce Loeb1

↓  
2.7  $\mu$ m  
↑

Figure 95

Edge Trace

CR-53 200 gm/kg

Joyce Loeb1

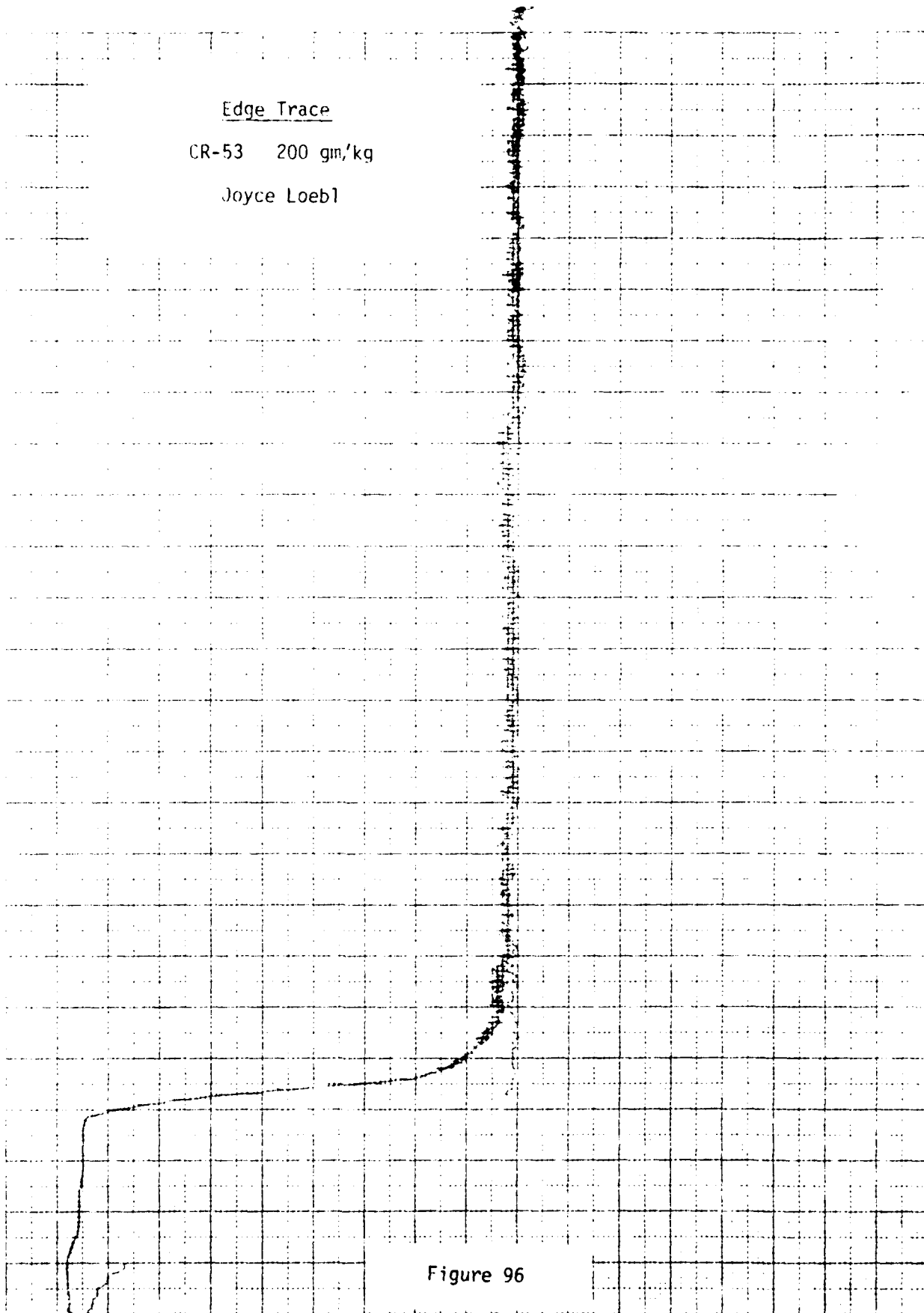


Figure 96

161510

161510

ESTERLINE

Edge Trace

CR-42 50 gm/kg

Mann

3.42

4.17 cm

Figure 97

PRINTED IN U.S.A.

## Edge Trace

CR-42 100 gm/kg

Mann

7.42 (3)

4.17  $\mu$ m

Figure 98

Edge Trace

CR-42 200 gm/kg

Mann

11-42 ③

4.17  $\mu$ m

Figure 99

## Edge Trace

CR-53 50 gm/kg

Mann

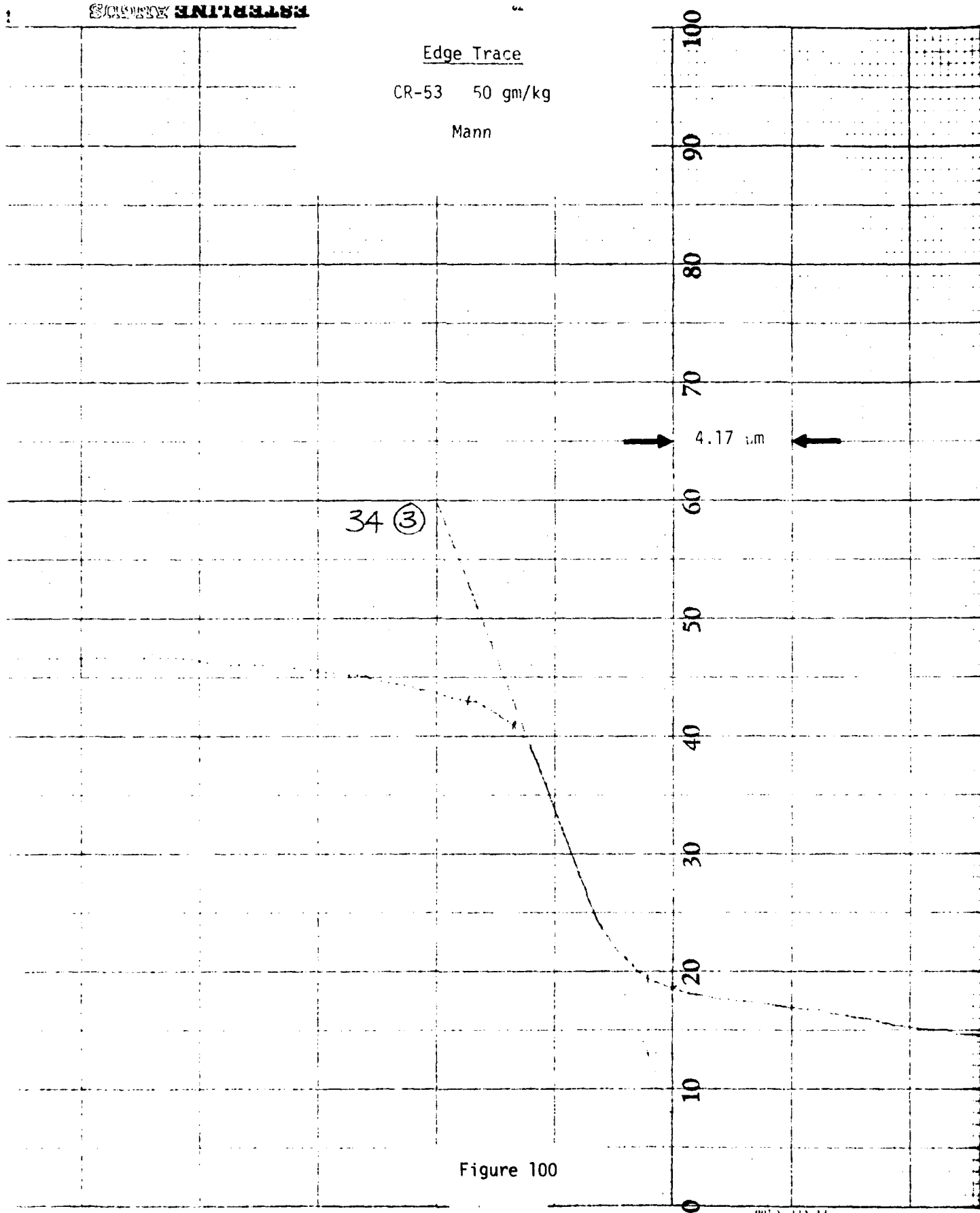


Figure 100

ESTABL

Edge Trace

CR-53 100 gm/kg

Mann

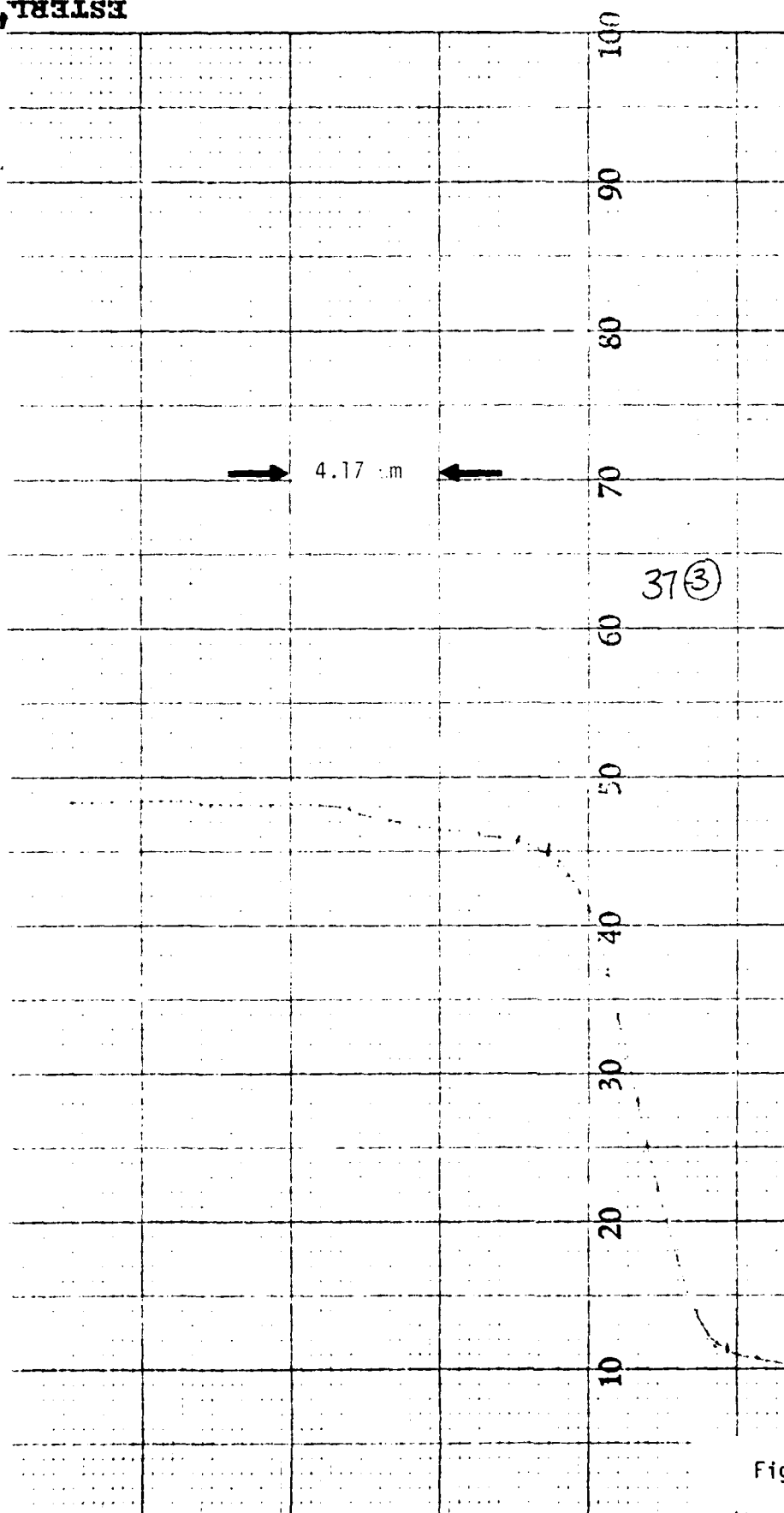


Figure 101

Edge Trace

CR-53 200 gm/kg

Mann

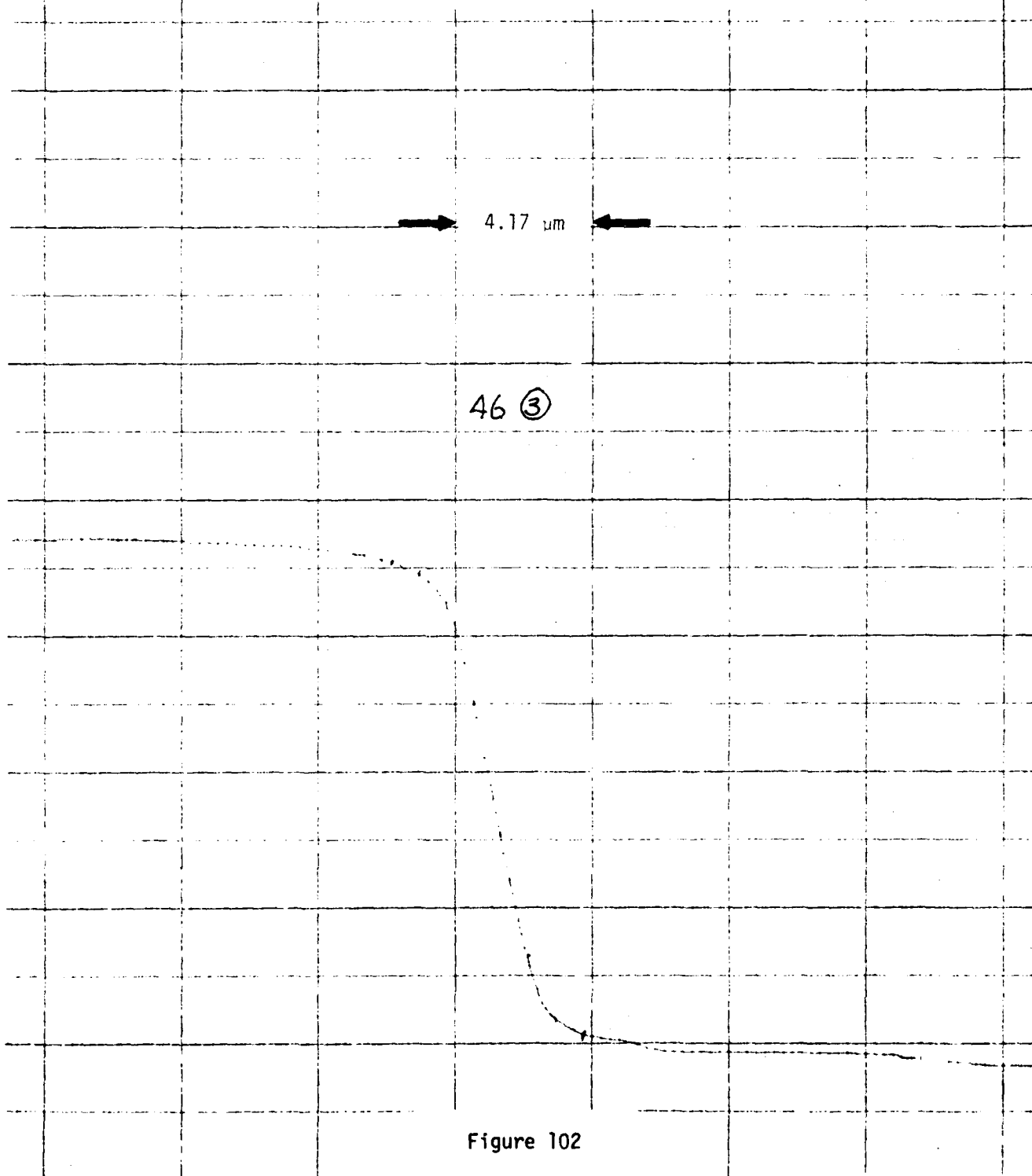


Figure 102

#### 4.0 CONCLUSIONS

From the data presented above, it is evident that KC-Film and toners show consistent, useful, and competitive performance with respect to these properties:

- (a) Resolution
- (b) Step Wedge Response
- (c) Uniformity
- (d) Gamma Range
- (e) Granularity
- (f) Acutance
- (g) Resolution vs. Delay After Exposure

#### 4.1 Electrical Parameters

Charge levels together with dark decay parameters were described in Section 3.1.1. These parameters are illustrative of films having useful properties. The voltage-log E response of KC-Film was described in Section 3.1.2. A useful characteristic of electrophotographic materials is that the effect of exposure can be measured electrically independently of the toning operation, which makes the charge pattern visible. Comparison of the V-log E with the various D-log E responses demonstrates that the D-log E response permits considerable manipulation for specific system requirements.

#### 4.2 Density as a Function of Toning Time

While maintaining a constant surface voltage (-20V) and changing the toning time, toner CR-42 permits D-max to be varied from near zero to  $\approx 4.0$ , and toner CR-53 permits D-max to be varied from near zero to  $\approx 3.0$ .

#### 4.3 Density as a Function of Surface Voltage

By varying the surface voltage while toning for a constant time (5 sec), the D-max with toner CR-42 can be varied from near zero to  $\approx 2.5$ ; while CR-53 provided a D-max from near zero to  $\approx 2.0$ .

#### 4.4 Density Uniformity

A mean density uniformity of approximately 3%, including densitometer error, was obtained.

#### 4.5 Gamma Range

With CR-42 the gamma was varied through the range of 0.4 to 3.5; while with CR-53 the gamma range obtained was from 0.3 to 2.5.

#### 4.6 Resolution

Resolution was studied several ways. A high contrast target was used as well as a multi-element target which provides both an exposure series and a contrast series of targets, each providing images from 10 to 500 cycles/mm.

##### 4.6.1 High Contrast Response

A USAF 1951 high contrast target provided by USAETL was imaged onto KC-Film. The film samples were read both by USAETL personnel and by Coulter personnel. The results follow:

		<u>USAETL Data</u>	<u>Coulter Data</u>
CR-42	50 gm/kg	256 cy/mm	406
CR-42	100 gm/kg	322	406/362
CR-42	200 gm/kg	161	406/362
CR-53	50 gm/kg	322	362
CR-53	100 gm/kg	362	406/362
CR-53	200 gm/kg	406	456/362

Under a separate contract, in 1978 a similar USAF 1951 high contrast target was imaged onto KC-Film. In this earlier work a resolution of 650 cycles/mm was observed and photomicrographs obtained for record. It is possible that the two high contrast targets were somewhat different.

#### 4.6.2 Resolution vs. Toner Concentration at Constant Surface Voltage

With CR-42 and CR-53, resolution is little affected by changes in toner concentration. From 50 to 200 gm/kg, changes in exposure make a greater difference as do changes in image contrast. Increasing the toning time with CR-53 from 2 seconds to 32 seconds again has no pronounced effect. A resolution of 500 cycles/mm was obtained over a contrast range from as low as 1.2/1 to 17.4/1; and in addition over an exposure range of  $\sim 60/1$ .

#### 4.6.3 Resolution as a Function of Surface Voltage Toned for a Constant Time

With CR-42, low contrast resolution decreases as surface voltage is decreased from 20 volts to 5 volts. The medium contrast targets (17.4/1) also show some decrease in resolution as surface voltage is reduced. Again changes in toner concentration over the range from 50 to 200 gm/kg have little effect on resolution.

#### 4.6.4 Resolution as a Function of Delay Time

Over the period of 60 seconds no real effects on resolution, due to image spread or dark decay, were observed with CR-42 and CR-53 at 50, 100, and 200 gm/kg concentrations.

#### 4.7 Granularity

Granularity was measured with both toners at 100 gm/kg. With CR-42 the RMS granularity is approximately 22, and with CR-53 it is approximately 15.

#### 4.8 Acutance

With toner CR-42 the average acutance over the three toner concentrations is  $3.1 \times 10^4$ , and with CR-53 it is  $5.0 \times 10^4$ . Variations in acutance were observed with respect to concentration of the toners; however, these variations are not clearly correlated with concentration. Variation in imaging conditions may be more important than toner concentration. At any rate, the acutance is high, especially with CR-53. Apparently, resolution in this system is more closely associated with acutance than with granularity. This is to be expected since the image is formed within a very thin layer; in addition, the optical image defines the areas for toner deposition, whereas with other photographic systems the photosensitive crystals are deposited stochastically before the image exposure is made.

#### 4.9 Operational Considerations

KC electrophotographic film and toners can be used to produce high quality imagery for numerous applications ranging from digital recording to lithography. Since the compounds used to make KC-Film are readily

available and used in small amounts, because of the thin photoconductive layer, KC-Film is a cost effective alternative to conventional photographic films containing silver.

The use rate of KC-Film will be a function of the particular application, and will be comparable to that of other photosensitive materials. The rate of toner consumption is a function of the area of the film processed as well as the nature of the imagery (average density).

KC-Film is insensitive to a wide range of storage temperature and humidity, and, until charged just prior to use, is also insensitive to light; thus the protection and handling of the material is very simple.

The storage and handling of KC-Film images is dependent on the type of toner used in their preparation, i.e., fusible or non-fusible. Images generated with fusible toners, once heat fused, are durable, and may be rolled or stacked without adverse effects such as blocking. Images prepared with non-fusible toners, on the other hand, are fragile and subject to mechanical damage. However, several protective overcoatings are available which afford images of archival quality.

No adverse physiological effects caused by the use of KC materials have been observed by personnel at Coulter Systems Corporation. However, contact of KC-Film with strong acids causes the liberation of hydrogen sulphide which is extremely toxic.

The preferred means for disposal of KC-Film is burial in a sanitary landfill.

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